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The Long Pattern Hypothesis in Harmony and Hearing

The tonal tensions and relaxations, the sequences and combinations of music are the common property of all musicians. That they are systematic, that an octave is a ratio of 2 to 1, and a fifth of 3 to 2, has been known from the time of Pythagoras, and perhaps earlier, but it has been impossible to show a reason for the effects of such ratios. As Leonard B. Meyer says: "Acousticians and psychologists from Pythagoras to Révécz have attempted to explain and account for the phenomena of consonance and dissonance on acoustical psychological grounds, but as yet no tenable, unobjectionable theory has been advanced*6:230.

The present paper attacks the old problem from a new approach, based on the concept that auditory perception cannot be understood as instantaneous, but involves processes of

3

by

PAUL BOOMSLITER

AND

WARREN CREEL

neural organization that take place through an interval of time. It follows that musical phenomena can be explained as relationships between long patterns of waves. Such a relationship we have termed the Common Long Pattern of a tonal combination. The fifth, in classical theory, is the ratio 3 to 2. The common long pattern of the fifth, for our theory, is a 1 to which both the 3 and 2 relate. This may in fact be physiologically marked by coinciding nerve impulses originating from the two stimuli, synchronizing at every third wave of one and every second wave of the other.

A re-examination of the theory of hearing is relevant to music because it supplies the premises for discussion of many musical problems. What is a key center, and what is tonality? Do musical relationships come from the overtone series, or par-

tial series, and can we find new musical resources by going farther up the partial series? What is the best source of new musical resources? Are musical relationships based on inherent properties of the auditory system, or are they products of custom, of cultural conditioning? These questions, and many others, inevitably direct the musical theorist back to the theory of hearing.

Starting with hearing, in order to arrive at musical premises, this paper suggests that the auditory nervous system may achieve sensations of pitch by coding sequences or long patterns of stimuli. This long pattern hypothesis offers explanations for a number of musical phenomena, including:

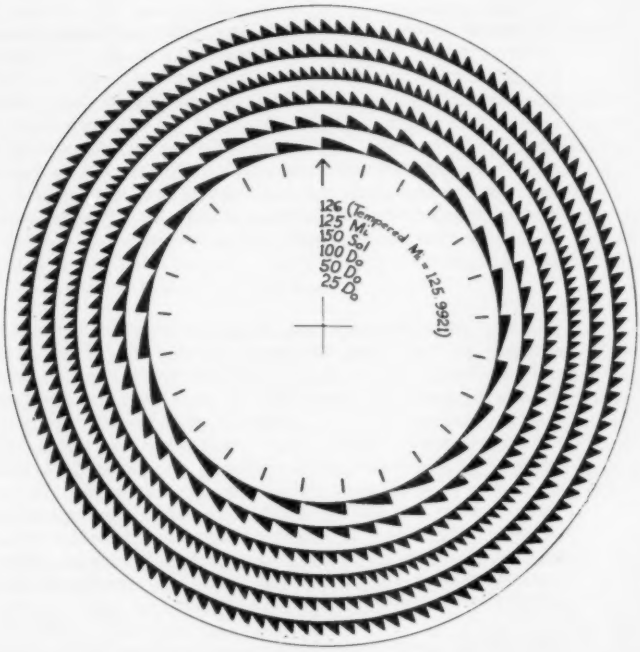
1 harmony phenomenon
2 noise-tone phenomenon
3 integration phenomenon
4 missing fundamental phenomenon
5 octave phenomenon
6 major-minor phenomenon
7 tonic phenomenon, resolution
8 melody phenomenon
9 vibrato phenomenon
10 mis-tuning phenomenon
11 approximation phenomenon
12 ensemble phenomenon

In the course of the paper a hypothetical nerve network is suggested that could accomplish coding of long wave patterns by known neural mechanisms. In general, the long pattern hypothesis provides an approach to the temporal aspect of hearing, which has not received due attention, and it serves to bring together and explain a number of previously unexplained and apparently unrelated aspects of hearing and music.

First on the list, the harmony phenomenon, will provide an example of the long patterns envisaged in the hypothesis. The harmony relationship is illustrated in Figure 1, which is a print of a tone disc that we use in experiments. The disc is a photographic negative, and the sawteeth, shown as black, are transparent. Each circle is, in effect, a sound track; the disc is rotated while light shining through a slit goes through the track and to a photocell, which generates electric current in proportion to the light falling on it. The varying current, shaped by the sawteeth, is fed through an amplifier and loudspeaker, producing a tone. The sawtooth shape of the waves in this disc produces a complex tone, with a rich series of partials or overtones. Thus, Figure 1 is a disc that produces musical tones when rotated in the proper apparatus. The pitch will depend on the speed of rotation, but the circles will keep their proportions to each other at any speed. For convenience we assume one rotation per second, which gives the frequencies written in the center.

figure 1

HARMONY DISC



The short radial lines inside divide the disc into 25 segments. Each segment is a long wave pattern. For the present we can ignore the two inner circles and the outside circle. The remaining three form a major chord: Do- Mi- Sol. Our sensation of harmony seems to indicate that these three notes have a kinship, that they share something. If we include time as well as frequency in our study of Figure 1 we see that they share a common long wave pattern, having four, five, and six waves respectively in each segment. Do and Sol share an even shorter common pattern, since each half-segment contains two waves of Do, and three of Sol, the common long pattern that would follow from a ratio of 3 to 2 in frequency, the interval of the fifth. The interval of the third, Do to Mi, is classically defined as the ratio of 5 to 4, and accordingly they share a common long wave pattern, with five waves of one and four of the other. All ratios of vibration create common long wave patterns of the same numbers of waves, by mathematical necessity.

Vibration ratios and shared long wave patterns necessarily occur together, in the case of sustained tones. Vibration ratio is, by implication, static. Common long pattern implies a process of organization taking place through time. Vibration ratios have been a dead-end street; no one has been able to produce a "tenable, unobjectionable theory" as to why a ratio should produce any auditory effect. In contrast, common long wave patterns supply the explanation for the auditory effects that are observed with ratios, and give us a fruitful hypothesis to explain many other musical phenomena.

The long pattern hypothesis is our own theory, being published now for the first time, but since circulating a draft of this article we have learned of two previous uses of some aspects of it. D. B. Irvine*14 suggested in 1946 that notes related by a simple ratio produce a "composite wave," which might account for the sensation of harmony. He did not suggest an auditory process by which the effect might be produced. The composite wave would work out mathematically the same as our long wave pattern. In 1885 and 1902 Theodore Lipps*15*16 treated musical vibrations as micro-rhythms, and held that notes in harmonic ratios would share a common ground-rhythm. This shared ground-rhythm would work out mathematically the same as our common long wave pattern.

Our own approach to shared long patterns as an explanation of

harmonic phenomena rests on a long pattern theory of hearing. We should be able to explain auditory effects by long wave patterns, if it can be shown that the ear uses long wave patterns in the process of perception.

We do need an interval of time to organize a sensation of pitch. Ekdahl and Stevens*9:101, using pure tones of very short duration, found that their subjects needed ten waves (1/100th sec.) of a thousand cycle tone to achieve a sensation of pitch. Anything shorter gave the sensation of a click. It is significant that the sensation from only ten waves was substantially lower than called for by the frequency, being equivalent to that from a sustained frequency of 842 cycles. Their subjects required about 30 waves (3/100ths sec.) of the 1000 cycle tone to organize a sensation of pitch appropriate to the frequency. Thus accumulation over a period of time is necessary for organization of a sensation of pitch, and, within a required period, less opportunity for accumulation results in a sensation of pitch lower than that appropriate for a sustained frequency. This suggests that pitch discrimination follows a long pattern of temporal accumulation.

Our own staggered frequency experiment indicates that the sense of hearing follows the long pattern rather than the frequency as a guide to the sensation of pitch when forced to make a choice. Figure 2 is a print of one of many tone discs which we have used in various forms of the staggered frequency experiment. The sawtooth waves produce complex tones; we have used many other discs producing other formants, including simple sine waves. Both simple and complex wave-forms produce the results outlined below.

The object of the experiment is to force the sense of hearing to make a choice between frequency and long pattern. Three circles, used for reference, have uniformly spaced teeth, and produce normal tones. The other three are staggered, with a group of teeth at one frequency and then a blank, producing a long pattern not appropriate to the tooth frequency. The ear reacts to the staggered frequency by hearing it as a tone (of poor quality) with a pitch corresponding to the long pattern rather than to the frequency.

In detail, the inner circle has 32 teeth, and if rotated ten times a second gives a pitch of 320 cycles. The second from the inside, with 34 teeth, would give a pitch of 340 cycles at this speed. The difference, a ratio of 17:16, amounts to a half-tone; if 320 is Do then 340 could be called Do-sharp. The

third from the inside, staggered, has 8 waves of the Do-sharp frequency, then jumps half a wave to get in step with the long pattern of Do. The sense of hearing interprets this as Do with distorted quality, using the long pattern as guide, since no Do frequency is present.

The fourth from the inside is again the Do-sharp frequency, but staggered by 4 1/4 waves instead of 8 1/2, and produces the Do sensation of pitch.

The next circle, second from the outside, with 36 teeth, gives a 360 cycle tone. The ratio to the inside circle is 9:8, a whole tone, the difference between Do and Re. The outer circle, staggered, uses the Re frequency for four waves, then jumps half a wave to get in step with the long pattern of Do. Again the sensation of pitch corresponds to Do, the long pattern, rather than the frequency.

Richard H. Dorf has presented a form of the staggered frequency experiment, using discs that produce sine waves. He noted*2:295 that "the total result, however, strange as it may seem, will be to produce the same frequency as with evenly spaced holes (though the sound will probably be unpleasant)." Dorf did not draw conclusions about the theory of hearing from this.

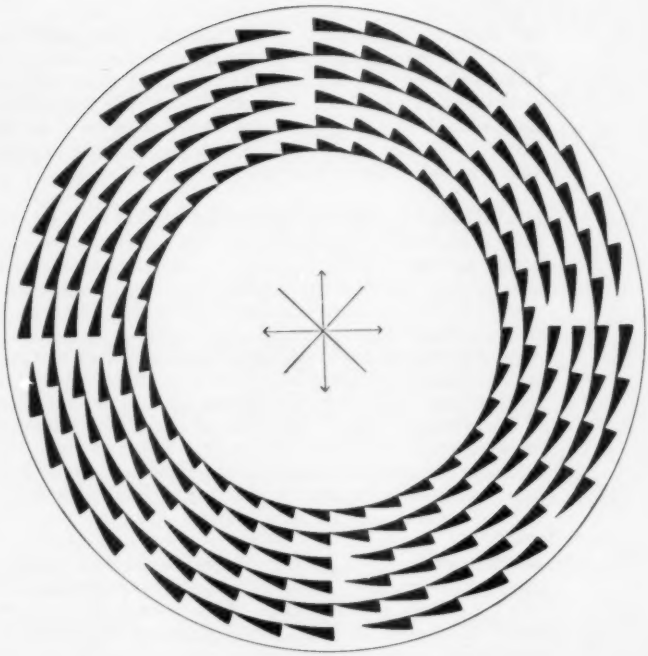
The staggered frequency experiment indicates that long patterns, which have not been considered as factors in hearing by conventional theory, are used by the sense of hearing in perception of pitch. From this it would follow that notes having long wave patterns in common, by this token have a certain element of their pitch organization in common. The common long wave pattern provides an auditory mechanism for harmonic relationships in music, while vibration ratio, considered by itself as it has been in the past, does not account for the relationships.

The other phenomena on the list bring out additional aspects of long patterns in hearing. The second is the noise-tone phenomenon, referring to the well-known fact that irregular frequencies produce sensations of noise, while sensations of pitch are associated with repeating frequencies, in which long patterns are possible. It may be significant that noise, containing no long pattern, creates no sensation of pitch.

Third is the integration phenomenon, referring to the fact that, in normal hearing of a complex tone, such as a human vocal

figure 2

STAGGERED FREQUENCY DISC



tone, with many partials, we integrate the entire complex, perceiving it through one sensation of pitch. By a special effort of attention we sometimes can hear a few separate partials in a complex for a brief time, but this is not normal hearing. (Incidentally, the fact that it can be varied by attention suggests that we are examining a process that takes place in the nervous system.)

A vocal tone may contain as many as thirty partials, with the energy well distributed among them, frequently with the fundamental very weak and the greatest amount of energy in high partials such as the 12th or 16th. Listening to a human voice or a musical instrument would be a very confusing experience if we had to cope with thirty separate sensations of pitch at the same time from such a tone. Our normal hearing, by integrating the complex into one manageable sensation, performs an essential operation for achieving a useable sensation of pitch.

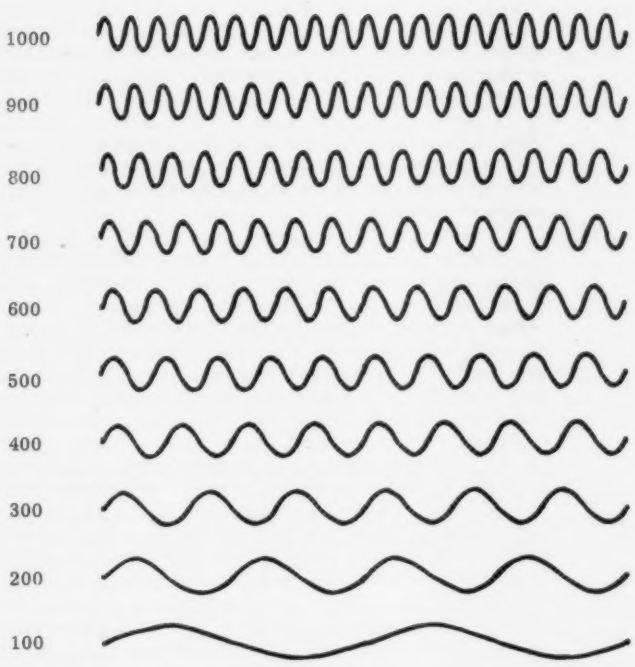
By what characteristic is the complex integrated to a single basis? It may be that the auditory characteristic of the whole complex is the common long wave pattern of all partials, which corresponds to the fundamental. Figure 3 diagrams the first ten partials of a complex tone at the frequency of 100 cycles. The dotted lines show the common long pattern of the complex, which is the same as the fundamental frequency.

It has been customary in auditory theory to take the simple, pure tone, of a single frequency, as providing the typical specimen for the sensation of pitch. The pure tone is a questionable choice as type specimen, since pure tones did not exist until laboratory apparatus was invented, while the sense of hearing began and evolved for millions of years as an instrument for perception of complex tones. It may be that the normal sensation of pitch does not represent perception of the fundamental at all, but represents instead the ear's perception of the common factor of the whole complex, the common long pattern of all partials. From this point of view a pure tone would present a special case, a crippled combination consisting of one item, in which the long pattern and the only frequency present are the same thing.

The integration phenomenon suggests that the capacity to organize a complex by common long wave patterns is an essential for efficient perception of even a single normal complex tone. If this is the case, then auditory organization of harmonies by common long wave patterns would appear to be a

figure 3

TWO CYCLES OF A COMPLEX 100 CYCLE TONE, SHOWING THE FIRST TEN PARTIALS



simple extension of the normal auditory process required in successful hearing of single tones.

Fourth on the list, the missing fundamental phenomenon, is a logical outgrowth of the integration phenomenon. It is known that we hear a complex tone with a sensation of pitch corresponding to the fundamental even when the fundamental and several other lower partials are filtered out. Telephones and cheap radios are such filters. The theory that the missing fundamental is restored in the inner ear through difference tones has been refuted by experimental evidence. For a detailed review of the evidence on this refutation see J. C. R. Licklider*4*5. A key article in refutation of the difference tone theory is that by Schouten*17.

The reader can illustrate the situation in cases of the missing fundamental by covering up the bottom two or three lines of Figure 3. It is apparent that the common long pattern will remain, shared by the other partials, even though the fundamental itself be gone. The puzzle of the missing fundamental is no puzzle at all if the frequency of the common long pattern of the series of partials is the source of the sensation of pitch.

Thus we are suggesting a new concept of pitch, based on the CLP (common long pattern). We suggest that pitch is an organized sensation representing the frequency of the CLP of a series of partials.

Pitch is generally treated as a sensation representing frequency, as assumed by Ohm's Law of Acoustics. The official definition chosen by the Acoustical Society of America wisely leaves pitch as an unsolved problem, defining it only as "that characteristic by which we classify tones as high or low." The idea that pitch represents frequency has far more exceptions than instances. Because they are complex, every vocal tone and every normal musical tone is an exception, for such tones contain many frequencies; but we hear them in normal listening as only one pitch. The missing fundamental phenomenon provides a notable exception, as does the staggered frequency phenomenon. Under the concept of pitch that we are presenting, these are instances, not exceptions. Another notable exception, the vibrato phenomenon (discussed below) may also be an instance under the long pattern concept of pitch.

The frequency concept of pitch assumes the rule: one frequency — one sensation. Our experience in normal listening is described better by the rule: one source—one sensation.

This gives us efficient listening for sensing the environment, and it can be explained by a CLP theory, while the frequency theory fails to explain it.

In the special case of a pure tone the frequency of vibration and the CLP are identical. The custom of taking pure tones as typical tones in acoustical experiments has tended to turn attention away from the normal operation of the sense of pitch, concentrating it on the special case.

The use of pure tones in acoustics follows from Ohm's Law of Acoustics, which asserts that the ear separates a complex tone into its partials, perceiving each frequency as a separate sensation of pitch. The followers of Ohm should realize that they apply the law more rigorously than Ohm himself. Ohm was aware that we hear a single sensation of pitch from a complex tone, and he called this "an illusion of the ear." Seebeck, another pioneer physicist, replied that the ear was the sole judge of auditory sensations, and that the mode in which it apprehended tones ought not to be called an 'illusion'. Helmholtz, commenting on the controversy, said that the hearing of a single sensation in a complex tone, or the hearing of separate partials, depends on "varying activity of attention." Helmholtz asserted that natural hearing, which produces a single sensation of pitch from a complex tone, is a low grade of perception, and that introspective laboratory hearing, assisted by apparatus, is a higher grade of perception. Helmholtz regarded separation, rather than organization, as high achievement. "Hence we can certainly appeal from the sensations of an ear directed without assistance to external objects, whose interests Seebeck represents, to the ear which is attentively observing itself and is suitably assisted in its observation [assisted by Helmholtz resonators to bring out separate partials]. Such an ear really proceeds according to the law laid down by Ohm." [For discussion of the original reasoning behind Ohm's Law of Acoustics see Helmholtz*3:49ff.] No psychologist today would agree with this rejection of normal sensation. Helmholtz and Ohm espoused the psychological theory of elements, which since has been abandoned by psychologists in favor of attention to wholes and wholeness tendencies. In spite of this, Ohm's Law of Acoustics, an offspring of the theory of elements, has not been adequately re-examined.

It is true, and significant, that we can, within limits, organize pitch sensations for some upper partials of a complex tone, even though we cannot maintain the special posture of attention for a long time. This suggests that the process of pitch-

organization takes place in the neural system, since no act of attention could alter mechanical vibrations of fluid in the cochlea. It is possible that the neural system accomplishes both analysis into separate frequencies and organization into integrated sensations.

Filters to remove lower partials of a tone are products of the laboratory age, but the phenomenon of the missing fundamental should not be considered a recent laboratory curiosity. The fundamental is weak in many tones, especially some human vocal tones. It must happen often under conditions of distance and noisy interference that the fundamental and a great deal more are masked out, yet speech does not change its pitch nor lose its intelligibility. Communication would be a poor thing if it failed us in a crisis. Our ability to maintain the patterns of speech through storm, battle, and uproar is one of the glories of human hearing. We attain this necessary mastery over interference by organizing our sensations from whole patterns, so that no single part is essential, and loss of a part is not loss of a sensation.

From this point of view, pitch-organization from the CLP appears as a vital operation in perception of single complex tones. The ability of the neural system to organize sensation by detecting the CLP exists for single complex tones, and thus is ready-made for organization of a harmonic relationship between two or more pitches by means of the CLP of the combination. Normal pitch-organization is the source of musical harmony.

The theory of harmony presented in this paper makes unnecessary, and in fact would eliminate, attempts to explain harmonic relationships as something learned by the ear from relations between the pitches of overtones or partials. This paper asserts that harmonic relationships are directly established by shared long wave patterns (which perhaps act through sharing of neural impulses, as will be discussed below). Our theory would deny that we learn anything from relations among the various pitches of the partial series, since it asserts that we hear only one pitch from a series, and that the organization of this singleness of pitch is the source of our capacity to organize harmony. It happens that the overtone or partial series theory does conflict with good musical practice in many ways. It will be impossible to go into a full refutation of the partial series theory here, since the topic would require a whole paper.

It also would follow, if this theory is correct, that good new musical resources are not to be found by going higher on the partial series, since that series was not a source of tones in the first place. It does not follow that there is no way to find new musical scales, harmonies, and resources. Our own experimental musical instrument, calibrated according to CLP theory, provides for 43 true-tuned notes within the octave, in a single key, without modulation, and we know of additional notes that would be desirable. Again, it is impossible to discuss scale theory within the scope of the present paper.

Fifth on the list is the octave phenomenon, referring to the ratio 2 to 1, a doubling or halving of frequency. The octave phenomenon, which has found no explanation in acoustical or musical theory, consists of the fact that our ears report that notes an octave apart are the same note, although in different pitches. Our hearing of this phenomenon indicates that a note and a pitch are not the same thing.

Frequencies separated by doubling or halving are different subdivisions of the same long pattern. Thus the note is probably our recognition of the long pattern, and the pitch our closer or sparser subdivision of it. We hear Low C, Middle C and High C as the same note, and this subjective sensation may be a report from the neural system: same hook-up but different subdivision.

In connection with the octave phenomenon it will be well to introduce the hypothetical nerve network which may apply to this and to all other phenomena connected with perception of pitch. It has been, and still is, customary in auditory theory to assume that the phenomena of hearing must be controlled in some unknown way by mechanical vibrations in the cochlea, the fluid-filled coil of the inner ear. The custom survives although exhaustive research on the cochlea has not produced satisfactory explanations of hearing. The earlier cochlear theories are refuted by the work of von Békésy and others. It is known that the inner ear is not like a harp, that there are no stretched fibers tuned for specific frequencies. Experiments show that there is some separation of vibrations according to frequency in the fluid of the cochlea, but the mechanism cannot produce the fine discrimination characteristic of human hearing. Thus we must look to the auditory neural system for at least a process for sharpening the detection of frequencies*12.

Recently, J. C. R. Licklider's auto-correlation theory of pitch discrimination has offered a possible method by which detec-

tion of frequencies could be accomplished in part or even entirely in the auditory neural system*4. It so happens that auto-correlation, when applied to long patterns, would serve to account for long pattern phenomena and the staggered frequency phenomenon. Figure 4 presents a simplified adaptation of Licklider's auto-correlation schematic (adapted from Figure 9 in his chapter). We have used fewer cross-over circuits, and have marked the parts specifically, but have made no change in the operation of the circuit.

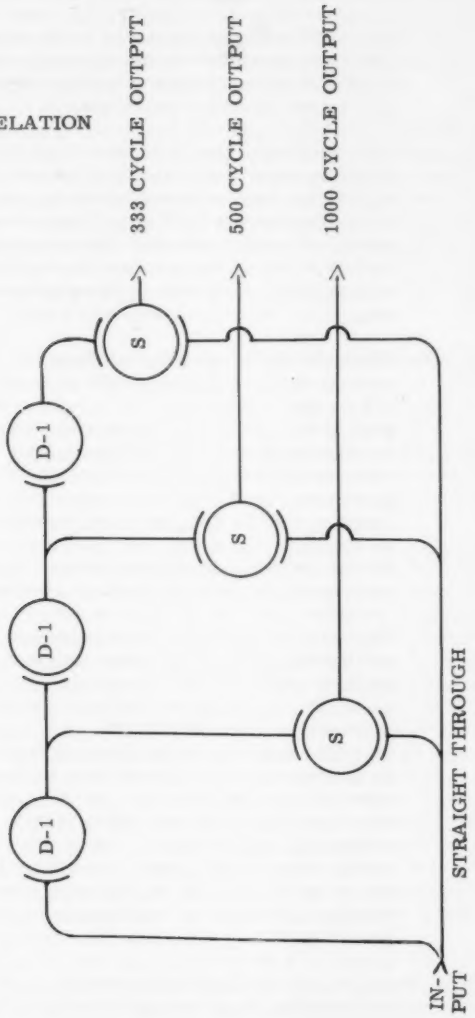
The impulses of the auditory nerve go through a sequence of several nerve centers on the way to the brain center of hearing, providing literally billions of alternative paths, with ample opportunity for cross-connection and organization. Figure 4 is drawn like an electrical circuit. The lines are nerve fibers, which act like wires, transmitting electrical impulses by an electro-chemical process that is only partly understood. Each circle is a synapse (the neurophysiologists' term for the connecting point where an impulse jumps from one nerve fiber to the next). Electronics has transistors, which pass electricity in only one direction, and relays, which are controllable switches; a synapse serves both purposes. The broad plates almost touching the circles symbolize controllable connections.

Each circle marked "D-1" is a time-delaying synapse, making a delay which we shall arbitrarily designate as one-thousandth of a second. (Such time-delay is known to be a property of some synapses, so the mechanism could exist in the auditory system.) The circles marked "S" are synchronizing synapses; they do not respond to a single stimulation, but only when they are stimulated by two coinciding, or almost coinciding, impulses. (Again, such synapses are known to exist.)

We assume that a five hundred cycle tone is stimulating the ear, producing five hundred volleys of nerve impulses per second. The first impulse comes from the ear to the Input fiber of this circuit, and goes through the Straight Through branch and also into the Delay Chain branch. Each synapse in the Delay Chain makes a delay of one-thousandth of a second. The first impulse meets no coinciding impulse, and hence does not go through to the Output at all. The second impulse comes through, and now, at the middle S synapse, it meets a coinciding impulse from the first wave, delayed 1/500th of a second by two D-1 synapses. The two coinciding impulses make the synapse fire, and the stimulus goes out the five hundred cycle fiber. The circuit has produced a fiber tuned specifically for

figure 4

AUTO-CORRELATION NETWORK



five hundred cycles. Auto-correlation provides a method by which a frequency-difference can be detected, and translated into a space-difference within the nervous system.

If a 1000 cycle tone arrived at the input it would synchronize after the first D-1 synapse, and go out the 1000 cycle output fiber. A 333 cycle tone would synchronize after the third D-1 and go out the 333 cycle output.

We should note that in Figure 4 the 1000 cycle fiber would respond to every second wave of a 2000 cycle tone, although less efficiently than a circuit tuned specifically for 2000 cycles. This may have a bearing on the octave phenomenon. It may provide a specific content for the concept of same neural hook-up but different subdivision, as the source of our subjective sensation of sameness in hearing tones in an octave relationship.

Thus, Licklider's auto-correlation hypothesis proposes a system that could analyze frequencies in the nervous system. (The schematic given here presents a key process, but only part of the auto-correlation process as Licklider envisions it.) In connection with it, Licklider remarked: "On the framework thus provided, the regular patterns of harmony (in music) and harmonics (in all periodic sounds except pure tones) set up common foci for integral multiples of a given frequency." Thus he assumes, as we do, an inherent process in hearing which favors integral ratios, rather than the view that musical patterns are arbitrary products of custom.

The controversy between inherent process and custom is crucial in musical theory. Many acoustical theorists assume that musical patterns represent cultural conditioning and nothing more, that there is no inherent property of hearing to favor pure ratios expressible in small numbers. Some musical theorists take the same position, that musical intervals rest on an arbitrary foundation, that we enjoy the classical intervals only because we are used to them, and that we would hear equal consonance in any other arbitrary intervals as soon as we became used to them. From this position the composer is free to choose any arbitrary combinations, and it is the function of the listener to become accustomed to them. This paper submits that musical consonances are the combinations that synchronize in the inherent mechanism of the auditory neural network. It is certainly true that cultural conditioning operates in systems of combination of intervals, which we call modes, and the Hindus call ragas. A mode or raga may be intelligible

only to a native of the culture. In spite of this, examination of music from various cultures reveals substantial agreement about the basic intervals [For Hindu intervals and ragas see Daniélou*1]. Our theory suggests that intervals are governed by inherent properties of the auditory system. If this theory is correct, new musical resources are not to be found by arbitrary adoption of intervals without regard to CLP's.

Licklider's network would not give an organized response to noises, since they are not regularly repeating impulses, and it requires a sustained periodic tone, or long pattern, since it operates through coincidence of delayed early impulses with later arrivals. Delay chains of this type could be hooked up to respond very sharply with high discrimination to long patterns. Figure 5 illustrates our concept of such a circuit. Each oval represents an entire delay chain. D-1 delays 1/1000th of a second; D-2 delays 2/1000ths, and so on.

If a 1000 cycle frequency came into the circuit of Figure 5, the fifth wave on Straight Through would coincide with the fourth wave arriving through D-1, and also with the third wave through D-2, and also with the second wave through D-3, and also with the first wave through D-4. Such a network, using accumulation of clues, could account for the time effects shown by the Ekdahl-Stevens experiment, and by the staggered frequency experiment.

A great many thousands of such neural hook-ups would be required to handle all the patterns of normal hearing, and more to provide the duplications of fibers for acting in relays, in accordance with Wever's volley theory of hearing*11, but this presents no problem, since fibers for millions of hook-ups exist in the auditory neural centers. The task of designing, linking up and calibrating such hook-ups would be one of incredible complexity. It is reasonable to assume that the system is self-designing and self-calibrating. In all human beings old enough to talk we are dealing with highly experienced auditory systems. It is likely, and experience in auditory training of deaf children indicates, that a new-born baby hears sounds as confusion, and that his neural network learns by experience to organize manageable sensations. It is conceivable that the auditory network develops synchronizations through experience, and that the network calibrates itself by these synchronizations.

We thus view synchronization as a potent, inherent neural device. Musical harmonies are relationships that can be or-

ganized by neural synchronization.

Obviously these schematics are oversimplified, while actual nerve organization would be more complex, full of cross-currents and side effects. It can be said that if any nerve circuits exist corresponding in principle to these schematics they would form a physical embodiment for the long pattern phenomena discussed in this paper. In the case of the octave phenomenon, with the ratio 2:1, it has already been mentioned that every second wave of the higher note could use the circuit of the lower note. In the case of the fifth, 3:2, every third wave of the higher note and every second wave of the lower could use the same circuit, and so on. Thus CLP's combining more than one note could be physically represented by shared neural circuits in the auditory network.

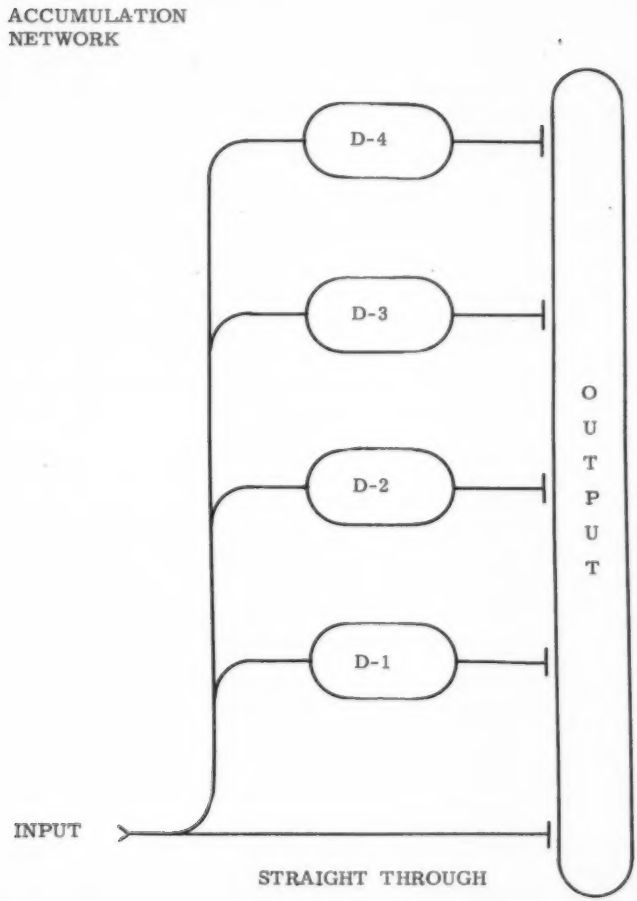
In normal musical hearing, genuine sharing of nerve circuits would require some adjustment for phase differences, but it is known, from the remarkable feats of the human ear in detecting direction, that we must have some highly efficient means for coping with phase. On the other hand, it is possible that musical kinship arises, not from use of the same circuits, but from use of different but identically organized circuits, in which case phase difference would be no problem.

Up to this point we have assumed the simplest case, relationship between pure tones. Normal musical tones, with many partials, provide far more facilities for overlapping. In the case of the fifth, 3:2, every third partial of one of the complex tones is identical with every second partial of the other. In the case of 5:4, every fifth partial of one is identical with every fourth partial of the other. In general, any numerical musical ratio can also be taken as a description of coinciding partials.

The coding of general relationships is a key problem in current neurophysiology. How do we perceive a square as a square, and a circle as a circle, regardless of size and angle of view? Electronic calculators do not do this. The sixth on our list, the major-minor phenomenon, bears on this. How do we identify a major chord as major, as different from minor, whether the chords are high or low in pitch? What are the general qualities of majorness or minorness?

The major chord is composed of certain frequency-ratios, hence of certain CLP's. Perhaps the major quality we hear in all such chords is a report from the nervous system: different

figure
5


ACCUMULATION
NETWORK
D-4
D-3
D-2
D-1
OUTPUT
INPUT
STRAIGHT THROUGH

pitches but organizable by similar hook-ups. Major harmonies, such as the fifth, 3:2, represent more possible shared neural organization than minor intervals, such as 6:5, the minor sixth, and this may serve as the basis for the different sensations that we identify in hearing.

We hear musical kinships between different tonal combinations which have neither pitches nor ratios in common, but share only a single feature of organization. For example, we hear a specific musical quality, which we call minor, in any musical ratio to five (which means, in every case, relationship to a long pattern of five waves). The following examples were chosen to use different frequencies in all cases:

600 cycles and 500 cycles make 6:5, a minor third.
525 " " 375 " " 7:5, a sub-minor third.
320 " " 200 " " 8:5, a minor sixth.
495 " " 275 " " 9:5, an acute minor seventh.

All intervals having ratios to five are heard as minor, and all intervals that are heard as minor have ratios to five. It would seem that the general minor quality shared by all these intervals may be a report from the nervous system that they are handled by similar systems of organization. If so, the phenomena of musical organization can supply valuable material for research in neurophysiology.

Seventh on the list is the tonic phenomenon, referring to the note Do of the scale, which satisfies and resolves a musical pattern. The tonic phenomenon has never been explained in acoustical or musical theory, although it operates in all musical cultures. A possible explanation for the tonic phenomenon can be seen in Figure 1. The third ring from the center, with four waves to a segment, is chosen by the ear as Do of the major chord. The second ring, with two to a segment, is Do an octave lower, and the inside ring, filling the segment, is Do still another octave lower. Our ears report that the three Do's are the same note, and we have seen in the neural circuits that they can be considered as different subdivisions of the same long pattern.

All the notes of the major chord fit into the CLP marked by one segment, but Figure 1 shows that Do has a special status; it does not merely fit into the CLP of the chord, but actually is the CLP, as seen in the inner ring.

We should expect the tonic of a combination to show some

characteristic that typifies all the notes of the combination. The long wave pattern hypothesis supplies a characteristic that meets the requirements.

Max Meyer published, in 1901, an experiment bearing on the tonic phenomenon*17. Sound any two notes related by a musical ratio, say 300 and 200 cycles, the ratio 3:2. Play them one after another, as a simple two-note melody, and ask listeners to choose the one they prefer as the ending note. They will pick 200. If the tones are related by 4:3, they will pick 4. If 9:8 they will pick 8. Their ears will choose as the preferred ending notes those represented by the ratio numbers 1, 2, 4, 8, 16, etc. For a summary of subsequent research on the power of 2, see Max Schoen*7:38. Schoen concludes: "Obviously, then, a pure power of 2 is preferred by far over other tones as a final tone." Although Max Meyer did not point this out, these powers of 2 are the only tones that can transpose down by octaves (or that represent subdivisions of the same long pattern) to be the CLP of the combination. The listener will have no marked preference for either note as the ending note when presented with 5:3, 6:5, etc., when neither note is represented by a ratio number that can be the CLP, although both fit into it.

Long pattern analysis shows a mechanism by which a certain combination can lead us to expect a certain note to complete and resolve the pattern. When we reach expectation we are touching the subject of structural meaning in music. As Leonard Meyer says*6:35, "From this point of view what a musical stimulus or series of stimuli indicate and point to are not extramusical concepts and objects but other musical events that are about to happen. That is, one musical event (be it a tone, a phrase, or a whole section) has meaning because it points to and makes us expect another musical event."

[It is obvious that not all musical notes are directly related to the tonic. Most melodies, after establishing the tonic, move into other harmonies, organized by relationship to a relative of the tonic, and return in the end to the tonic to resolve the melody. Such indirect reference does not diminish the role of the tonic as the reference note and resolver of the pattern. The long wave pattern hypothesis supplies a substantial amount of material on musical scales and melodic organization, too lengthy for this article.]

Eighth is the melody phenomenon. Musical ratios as melodic intervals have the same general effect and sound that they have as harmonies. Thus a melodic interval of 6:5 sounds minor,

as does that ratio as a harmony. The harmony is a relationship between two or more notes sounded simultaneously. In melody we have the same effect from a tone sounded and another tone not sounded, as in the case of the 6:5 melodic interval. Since the tone not sounded is participating in the effect, it must exist in some form. We have assumed in the case of harmony that the two notes are sharing a common neural hook-up. In the case of melody we must assume that the neural hook-up of the tone not sounded is being projected, that the note sounded is being heard in part through the neural hook-up of the tone not sounded, and thus that a projected note and a sounded note share a CLP. Melody is a strong auditory device, suggesting that auditory projection is a strong phenomenon. This raises the possibility, which should be investigated, that projection is involved, not merely in relations between two notes, but in perception of a single tone. The Ekdahl-Stevens results suggest this, since the sensation of pitch starts lower than that appropriate to a continued frequency, and changes upward as additional clues come in. It may be that higher sensory centers, acting through the reticular network, are projecting a tentative hook-up for the incoming signal, and are progressively revising and correcting it as additional signals come in. In any case, the persistence of a tonic as a reference through complicated melodic patterns could only be possible through some projection system.

Ninth is the vibrato phenomenon. Vibrato phenomena suggest that we might look to a span as long as one-sixth of a second as a possible organization-time in the human auditory network. Vibrato, present in all good singing voices and many musical instruments, is a rapid fluctuation in frequency that does not produce a fluctuation in the sensation of pitch. The fluctuation in frequency may be quite large, often equal to a musical semi-tone, and may be even more without changing the steady sensation of pitch. The normal rate of fluctuation in good vibrato is between six and seven per second, as found in a study by Carl Seashore*8. If the rate falls below five per second the steadiness of the sensation of pitch disappears and we hear a pronounced and unpleasant wobbling of the pitch (as may be tested by reducing the speed of a phonograph record). Seashore described our steady sensation of pitch during the frequency fluctuations of a vibrato as an "illusion." This calls to mind Seebeck's objections to Ohm's Law of Acoustics.

The staggered frequency experiment showed that the sense of hearing uses the long wave pattern as one factor in governing the sensation of pitch. During a vibrato the long pattern does

not change, although the frequency fluctuates. Figure 6 illustrates this.

The pattern from peak to peak of the low frequency sections is equal to the pattern from peak to peak of the high frequency sections. Perhaps in a vibrato we hear a steady sensation of pitch because one of the prime physical bases of pitch, a long pattern, is indeed steady, without any illusion.

Vibrato gives us not only a steady sensation, but an improved, enriched sensation of tone. Perhaps the frequency fluctuations in vibrato serve in some way to call additional nerve paths into play, thus enriching the neural signal while keeping the long pattern unchanging.

Tenth on the list is the mistuning phenomenon, referring to the spectacular ability of the human ear to detect slight departures from a true tuned relationship. An aspect is illustrated by the outer circle of Figure 1. This ring, with 126 waves to a full circle, is tempered Mi in relation to Do, while true Mi has 125 waves. The difference seems negligible to the eye, yet is clearly perceptible to the ear, which can detect much smaller mistunings under test conditions. We see a possible explanation by taking the temporal aspect of hearing into consideration, if we look from the top of Figure 1 to the bottom. After half a rotation the waves of tempered Mi have shifted squarely out of phase with true Mi, and with Do. Thus accumulation of a pattern in time can serve as a vernier, enlarging a small difference to manageable proportions. This may account for some of the otherwise inexplicable feats of the human ear in frequency discrimination.

Eleventh is the approximation phenomenon. If Do is sounded, and then tempered Mi, we do not hear the latter as a tone in its own right; we hear it as a slightly sharpened true Mi, as a slightly mistuned approximation of true Mi. The reverse does not happen; we do not hear true Mi as an approximation of tempered Mi. The approximation phenomenon indicates that the ear prefers a synchronizable relationship over a pair of unrelated, unsynchronizable tones. If a tone approaches the pitch for a synchronizable relationship it is interpreted as an approximation of it. The approximation phenomenon makes it possible for instruments in tempered tuning to convey patterns even though they do not supply them accurately.

Musical practice abounds in approximations, which offer rich material for study of neural coding, since the choice of an ap-

proximation is an indication of codability. An interesting instance of this appears in the history of musical research. Stumpf found that musical ratios with the smallest numbers, such as 2:1, 3:2, 4:3, produced stronger sensations of fusion than ratios with larger numbers*10:1. Faist, seeking to verify Stumpf's laws, reached some results that he interpreted as exceptions*13:189. For example he found that the tritone, with the ratio 45:32, produced a better effect of fusion than the second, 9:8, or the seventh, 15:8.

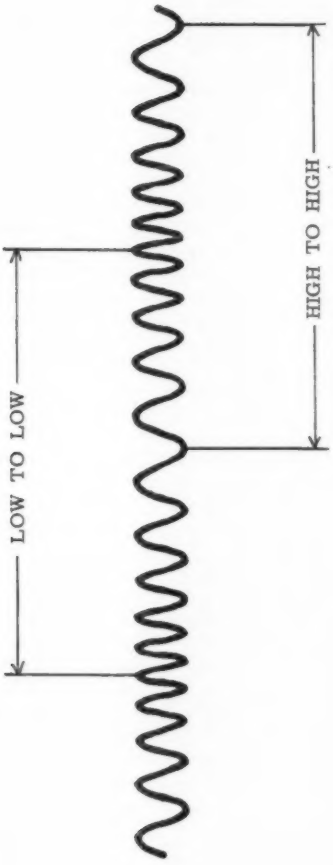
The paradox calls for explanation. In a consonance, such as the fifth, 3:2, every second wave of the lower frequency corresponds with every third wave of the higher frequency (although we do not know the neural form of this correspondence). We can hear that 17:13 is dissonant, and can readily understand the lack of fusion, since only every 13th wave of the lower corresponds with every 17th wave of the higher frequency. We might well suppose that this is not enough correspondence for coding. It would be most remarkable if the capacity for neural coding should suddenly re-establish itself at 45:32, when only every 32nd wave of the lower frequency corresponds with every 45th wave of the higher.

Subjective observation removes the paradox. The tritone is heard as a mistuned fifth, 3:2. The ratio 45:30 would be a precise 3:2, as would 48:32. The strict tritone, 45:32, is certainly mistuned, but the auditory system can force it into an interpretation as 3:2, while hearing also that it is mistuned, and does so. The point is that 3:2 is codable by the neural network, while 45:32 is not codable in its own right, so it is interpreted as an approximation to something that is codable. Hence, the chosen approximation is an indication of codability, and the phenomena of approximation should yield rich information on the coding preferences and capacities of the neural network.

The twelfth on the list, the ensemble phenomenon, is an extremely puzzling one. We hear a group of voices, singing in chorus, in correct pitch. In the simplest terms, if we hear four tuning forks, each vibrating 250 times per second, all sounding together, we do not hear a pitch of 1000 cycles, but a pitch of 250, slightly richer than a single fork sounding alone. Somehow the vibrations that belong together are sorted out and sensed in relation to each other, although there is nothing in the intricate vibrations of the ear drum to identify one vibration as belonging with another. A truly satisfactory answer to this requires extensive investigation, but the long

figure
6

EQUAL LONG PATTERNS
IN VIBRATO

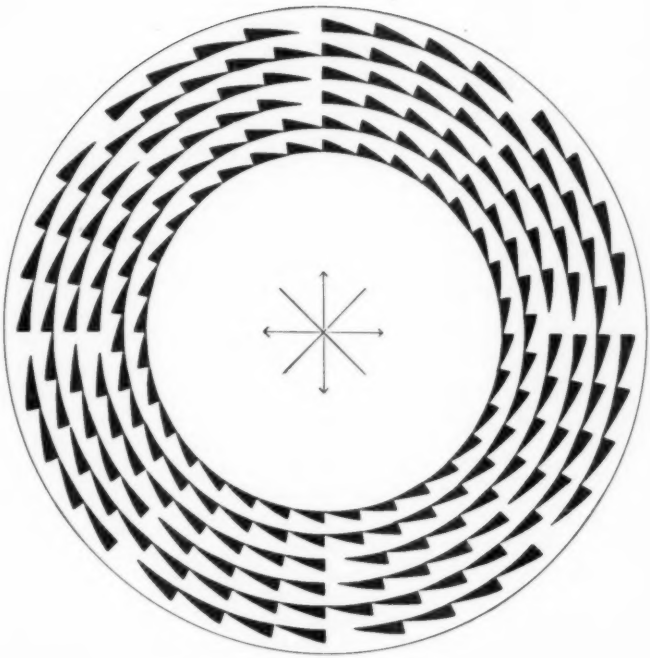


pattern hypothesis supplies a possible mechanism by which the sorting could be done. The waves from each source would provide consistent long patterns with each other, hence the long pattern could serve as a means of sorting.

In conclusion, this paper suggests the hypothesis that the auditory system achieves sensations of pitch by neural coding operating through time. The hypothesis brings together a number of apparently separate phenomena under one explanation, and this fact is persuasive, but thorough experimental research remains to be done in many areas suggested by this survey.

The approach taken here, if correct, would lead to a number of conclusions in musical theory. Long patterns are components in the sensation of pitch. Harmony is produced by shared long patterns. A tonic is a note representing the common long pattern to which all the notes of a given combination refer, and tonality then would be the feeling of reference to a single long pattern. The melody phenomenon indicates that auditory reference may operate by projection. Musical harmony comes from an extended application of the system of organization that produces a single sensation of pitch from the series of partials in a complex tone. Thus the unification of a complex tone, rather than a supposed separation of it, is the foundation of musical organization. There are no harmonic relations between partials as separate pitches, the partial series is not the source of musical organization, and new musical notes are not to be found by going higher on the partial series. Musical relationships may represent synchronized impulses in the auditory neural network, and hence the basic musical intervals would be governed by inherent characteristics of the auditory system, not by custom nor arbitrary choice.

The bulk of this paper has necessarily been devoted to a hypothesis about hearing. The hypothesis is not established and is sharply in conflict with the prevailing assumption in the sciences of audition that the phenomena of hearing should be explainable somehow by the mechanics of vibration in the cochlea. We believe that it is the responsibility of a theory of hearing to account for the primary phenomena of music, and the cochlear approach has signally failed in this respect. The hypothesis sketched here at least attempts to answer some of the musical problems that properly rest on a theory of hearing.



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Vicentino's Arciorgano; an Annotated Translation

Essendo cosa manifesta ad ogn'uno che il tenere ascose quelle cose che possono giouare al mondo, torna di grandissimo biasmo. Il Reuerendo Don Niccola Vicentino di Vicenti non volendo incorrere in questo errore, fa per la presente manifesto, per beneficio vniversale della Musica, come egli con lunghissima fatica e continuo studio, ha ritrouato & posto nouamente in pratica vno Arciorgano di mirabilissimo artificio & armonia, il quale si vede manifestamente hauer suplito a molte imper-

33

by

HENRY W. KAUFMANN

On October 25, 1561, Nicolo Bevil'acqua published a broadsheet at Venice that described the Arciorgano of Nicola Vicentino, a portable instrument, similar to his Archicembalo, which was capable of playing music in the diatonic, chromatic and enharmonic genera. The text of the original and a translation into English follow*1:

It is a fact clear to everyone that to keep those things hidden, which could be of use to the world, deserves the greatest censure. The Reverend Don Nicola Vicentino di Vicenti, not wishing to fall into this error, makes plain, for the universal benefit of music by means of the present document how he, after the longest effort and by continuous study, has invented and recently put into practice an Arciorgano of the most wonderful artifice and harmony which one sees manifestly to have made

fettioni che si ritrovano ne gli Organi ordinarii, & haver fatto l'organo perfetto.

Messer Vicenzo Colombo, eccellentissimo in questa professione di organi, è stato quello ilquale, ha posto in opera il detto Arciorgano secondo l'inuentione de l'armonia de l'autore, il quale con stupendo artificio l'ha in questa forma ridotto.

Tutte le canne son fatte di legno, accioche stia lungo tempo accordato, e renda dolce intonatione; la canna piu lunga è di sette piedi, ma per commodità di poterlo portare a viaggio, le sette canne maggiori sono state voltate di sopra in giu, tal che la canna piu lunga in apparentia nella facciata dinanzi rimane di cinque piedi, & questo si è fatto a fine che si possa trasportar di loco in loco per commodità di quei Principi che'l voranno godere.

Tutto disfatto e posto ne i suoi forcieri non serà la carica d'vn mulo, e sarà facile il metterlo insieme, e non v'andra piu tempo di quattro o cinque hore.

Il numero de le canne sono in tutto cento venti sei di voce graue e dolcissima, & ha cento ventisei tasti & altre tanti catenacci: le canne son poste in quattro ordeni in modo di vna mitra & col sommiero tanto bene ordinato, con cento ventisei animelle, che per il suo marauiglioso artificio, oltra la sua dolcissima armonia, è bellissimo da uedere, con cento ventisei tasti, son talmente disposti che rallegrano a vederli commodi alla pratica del sonatore, accommodati in si breue spatio, che non occupano piu luogo della lunghezza & larghezza della tastatura ordinaria de ogni organo.

L'acquisto, e la richezza dell'armonia, e di gradi che ha con tante corde aggiunte alla tastatura del comune orgono, che tutte mancauano; e questa, che ui si guadagna tutta la Musica perfetta Diatonica semplice e mista, e cinque sorti di consonantie in tal pratica mai piu non vdite ne vsate.

Prima si son guadagnate le quinte perfette sopra i tasti bianchi del comune organo che fanno vno vdir mirabile, poi due sorte di terze, vna maggiore, & l'altra minore, e similmente due sorti di seste doue auiene che quando le quinte perfette son tocatte insieme con le terze perfette, empieno di tanta armonia l'orecchie, che meglio in terra non si puo sentire.

up for many imperfections that are found in ordinary organs and to have constructed the perfect organ.

Messer Vicenzo Colombo, most excellent in this profession of organ building, has been the one who has put into operation the said Arciorgano according to the harmonic invention of the author, who, with stupendous artifice, has reduced it to this form.

All the pipes are made of wood so that they stay in tune a long time and give a sweet intonation. The longest pipe is seven feet, but for the convenience of being able to carry it while travelling, the seven larger pipes have been turned down from above, so that the longest pipe, seen from the front, remains five feet in appearance. And this is done for the purpose of being able to transport it from place to place for the convenience of those princes who wish to enjoy it.

All disassembled and put into its chests it will not weigh more than the [average] load of a mule, and it will be easy to put it together and will not take more time than four or five hours.

The number of pipes are 126 in all, low and very sweet in sound. And the instrument contains 126 keys and as many stickers. The pipes are placed in 4 orders in the manner of a miter and with the wind-chest so well arranged with its 126 valves, that the instrument, by its marvelous workmanship besides its most sweet harmony, is most beautiful to behold, with 126 keys. These are ordered in such a way that it is a delight to see them adapted to the practical needs of the performer, accommodated in so small a space that they do not occupy more room than the length and breadth of the ordinary keyboard of any organ.

The gain is [found] in the richness of the harmony and of the steps which the instrument possesses due to so many strings added to the keyboard of the common organ which all of them lacked. It is this which obtains here all the perfect diatonic music, simple and mixed, and five kinds of consonances in such practice never before either heard or used.

First there are obtained perfect fifths above the white keys of the common organ, which make a wonderful sound; then two kinds of thirds, one major and the other minor, and similarly, two kinds of sixths, in which case it happens that whenever perfect fifths are struck together with perfect thirds, they fill the ears with such harmony that no better can be heard on earth.

Si sono ancora acquistati molti gradi d'accenti che fra tasti si ritrouano, accommodati, a varie sorti di pronuntie, simili alla pronuntia humana, di modo che proui pure vn cantore de intonar qual si voglia vocce, l'organista haurà sempre modo di rispondergli nel medesimo tuono sopra vno de tasti del detto perfetto organo, e sopra di quello potrà dar principio a sonar de tutti i tuoni, cosa di ammiratione grandissima nella professione della Musica, il simile auerrà nelle chiese, che ogni Maestro di cappella potrà intonare, o fare intonare, qual si voglia voce in choro che tornerà commoda a suoi cantori & l'organista col detto instrumento sempre risponderà in tuono, e se per forte, cantando i cantori, cresceranno ouer caleranno, l'organista potrà sempre accordar co' cantori nel fin de la lor voce, con bel modo potrà ritornare nella prima intonatione, che alcuno non se n'accorgerà.

Si ha ancor in questo instrumento questo guadagno che nel concertare varie sorti d'instrumenti non occorre accordarli con detto Arciorgano, ma sia qual sonatore si voglia di liuto di viola o d'altro, potrà accordare indisparte a suo modo il suo liuto, o la sua viola sempre accorderà con detto Arciorgano, perche è di tal ricchezza, e perfettione che ha il modo di accordarsi subito, con tutti gli istrumenti e con tutte le voci.

Si è fatto questo primo d'vn registro solo, ma si potranno gli altri far di piu registri, e da camera e da chiesa secondo l'intentione di chi vorra seuirsene.

Sopra questo instrumento si posson sonare tutti i tre generi della Musica cio è il Diatonico, il Chromatico, & l'Enarmonico, in ogni tasto caminando però d'vno in altro tasto, & anchor tutte le sorti di Musica, antiche, & moderne con commodità di comporre, e di sopra cantare, e sonare tutti i modi di cantari e di aeri secondo l'idioma che da natura cantano tutte le nationi del mondo, cio è se l'inuentore della sopra detta armonia, sentirà cantare vn Spagnuolo, vn Francese, vn Polonio, vn'Inglese, vn Turco, o vero vn'Hebreo, ancora che tutte le nationi del mondo stan differenti di pronuntie, e di varii accenti, egli scriverà e comporrà a quattro & a piu voci quel suo cantare con maggiore armonia, & con piu consonantia che no si fa nella Musica comune, e potrà dette compositioni cantare e con gran diletto de gli ascoltanti sopra il detto Arciorgano.

There are also obtained many gradations of accents which can be found among the keys, accommodated to various kinds of pronunciation, similar to human pronunciation, so that you can prove it merely [by having] the singer intone any pitch that he wishes, [and] the organist will always find the way to respond to him with the same tone [played] on one of the keys of said perfect organ. And more than this, he will be able to begin playing from any tone — a thing of the greatest admiration in the profession of music. The same will happen in churches, that any chapel master can intone or have intoned for his choir any pitch that will prove suitable to his singers, and the organist, with said instrument, will always respond in pitch. And if by chance, while the singers are singing, they sharpen or flatten, the organist can always agree with the singers when they reach their final tone, [and] with a fine manner, he can return to the first intonation, and no one will be aware of it.

There is also in this instrument this advantage: that in the playing together of various kinds of instruments, it is not necessary to tune them with said Arciorgano, for whatever player one wishes, be it of the lute or of the viola or of any other instrument, he can tune his lute or his viola, regardless of his method, and it will always be in tune with said Arciorgano because it is of such richness and perfection, that it can tune itself at once with all instruments and with all voices.

This first [Arciorgano] is made with only one register, but others can be made with several registers, and for the chamber or the church, according to the desire of him who wishes to make use of it.

On this instrument one can play all three genera of music, that is, the diatonic, the chromatic and the enharmonic, on every key, moving, however, from one to the other, and also all kinds of music, ancient and modern, with the convenience of composing, and above all of singing and playing all manner of songs and airs according to the idiom which all the nations of the world sing. That is, if the inventor of the aforesaid harmony were to hear a Spaniard, a Frenchman, a Pole, an Englishman, a Turk, or a Hebrew sing, since all the nations of the world differ in pronunciation and vary in accent, he will write and compose his song for four and more voices with greater harmony and more consonances than one does in the usual music, and he will be able to sing said compositions to the great delight of the listeners with the [aid of] said Arciorgano.

Molte altre commodità sono in detto instrumento, come sarebbe a dire da imparare a sonare, & a cantare le pronuntie delle passioni delle parole, cosa che non si puo se non in qualche parte nella comune Musica; quando dolce, quando amaro, quando allegro, quando mesto, quando soaue, quando aspro, quando ombroso & oscuro, e quando lucido, e chiaro, quando pio e diuoto, e quando crudele e disperato, quando di lamentatione e di pianto, quando di allegrezza e di iubilatione, quando morto, e quando viuo, secondo l'affetto che vuol muouere il sonatore; tutto questo appresso a gli altri, e stato grandissimo acquisto, hauendo ritrouato il modo del cantare, e con armonia comporre, e sonare, i modi del cantare di tutte le nationi del mondo.

Piu oltre tra gli altri modi di comporre e di sonare, ve n'è vno da comporre vna Musica da far recitar, ad vn cantor solo con l'intrumento, e sarà Musica tale, che da quello s'vdirà recitare ogni sorte di parole, ouer parlar alquanto also accompagnato dall'armonia.

Tutte le sopradette cose ogni giorno sono vedute, & vdite da molti Signori, & gentilhuomini, & da molti altri, e chi piu s'intende di Musica, piu si marauiglia di tale inuentione, conoscendo chiaramente, che con detto instrumento, gli eccellenti pratici de la Musica commune possono imparare a sonare & a cantare questa noua Musica in vn mese, o poco piu, secondo che piu e meno vi faranno studio.

L'autore di detta armonia, ha seco vn Clauicembalo fatto al modo dell' Arciorgano con altre tanti tasti per poter studiare sopra quello, e fin' hora egli vi sona alquante compositioni, che ricercano, parte diatonicamente tutti i tasti, e parte misti di varie sorti de gradi, caminando da vn tasto all'altro con belli accordi in proposito delle parole con vario proceder d'armonia e de gradi.

L'Inuentore di questo Arciorgano l'ha voluto publicare, a fine, che se ad alcuno di quelli Principi che si dilettano di fauorire quelle inuentioni che diano giouamento a l'arti & a le scientie, e conseguentemente al mondo; piacesse d'vdirlo, o di porlo in pratica se ne possi preualere facendo saperea quel generoso Principe che'l detto inuentore, gli donara il Clauicembalo, l'Arciorgano, e se stesso offerendosi d'insegnare il modo di sonarlo ad ogn'vno che ne sarà desideroso, & appresso d'insegnar di cantare quei due generi di Musica, che hoggi non sono in vso i quali si potranno cantare, nelle chiese & nelle

Many other conveniences are [found] in said instrument, as, for example, in learning to play and to sing the expression of the passions of the words, a thing which can only be achieved partially in the usual music: [that is] when it is to be sweet, when bitter, when happy, when sad, when suave, when harsh, when shadowy and obscure, when lucid and clear, when pious and devout, when cruel and desperate, when lamenting and weeping, when rejoicing and jubilating, when dead and when living, according to the effect which will move the player. All this in addition to other [advantages] has been acquired in the grandest way by having discovered the method of singing, and composing in harmony, and playing, the musical procedures of all the nations of the earth.

Furthermore, among the other modes of composing and of playing, there is one of composing [a type] of music that involves recitation by a solo singer with the instrument, and it will be such music that in it one will hear recited every sort of word or rather lofty speech, accompanied by harmony.

All the above mentioned things are seen every day and heard by many lords and gentlemen, and by many others, and who, the more they understand music, the more they marvel at such an invention, since they know clearly that with said instrument the excellent practitioners of the usual music can learn to play and to sing this new music in a month, or a little more, depending on whether they apply themselves a lot or a little.

The author of said harmony has in his possession a Clavicembalo, made in the manner of the Arciorgano, with just as many keys, in order to be able to practice on it. And up to now, he plays on it some compositions which employ all the keys, partly diatonically and partly mixed with various kinds of steps, moving from one key to the other with fine chords, [always] in accordance with the words and with a varied procedure of harmony and steps.

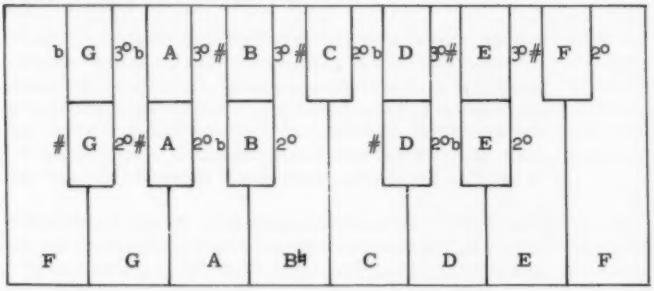
The inventor of this Arciorgano has wished to make it public so that if any of those princes who takes a delight in favoring those inventions which are useful to the arts and sciences, and consequently to the world, should be pleased to hear it or put it into practice, provided that he can avail himself of it, let it be known to that noble prince that the said inventor will give him the Clavicembalo, the Arciorgano and himself, by offering to teach the method of playing it to anyone who would be desirous of it, and also to teach the singing of those two genera of music, which are not in use today but which can be sung in

camere, & communicarà quelli ad ogn'vno, a laude del'eterno Idio, & tutta quella virtù, che con vn studio di tanti anni s'ha acquistata, per beneficio del mondo, & a perpetua memoria de presenti, & di quelli che verranno dopo noi per molti secoli.

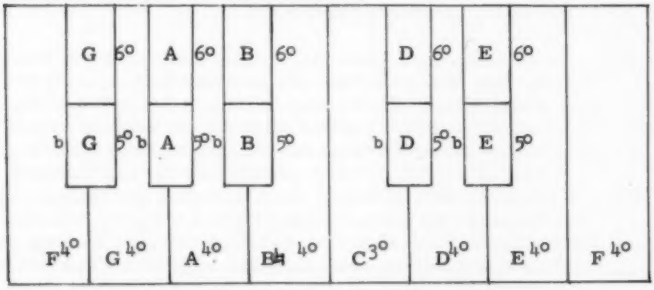
In Venetia, Appresso Nicolo Beuil'acqua.
1561. Adi 25. Ottobrio

example 1

FIRST FRAME OR KEYBOARD



SECOND FRAME OR KEYBOARD



churches and in chambers, and he will transmit the knowledge of these to anyone, to the praise of the eternal God, and all that competence which, with a study of so many years, he has acquired, for the benefit of the world and to the perpetual memory of the present generation and to those who will follow us through many centuries.

In Venice, by Nicolo Bevil'acqua.
The 25th day of October, 1561.

The need for a portable Arciorgano rather than the less mobile Archicembalo may have been occasioned by Vicentino's campaign on behalf of his enharmonic genus throughout many important cities of Italy. Galilei reports that Don Nicola, at some time in his career,

> had a number of pupils who, particularly while he played the enharmonic, sang that genre of music composed by him. He let this music be heard in all the principal cities of Italy and I personally heard it at various times and places on a number of occasions*2.

Some of these performances may even have taken place before 1560*3, since Galilei refers to one of Vicentino's pupils, Giacomo Finetti by name, whom he had met at Venice in that year and who told him "that wishing to settle down, he found it necessary to lay aside his master's enharmonic and attend to other things."*4

The claims asserted for the Arciorgano resemble those made for the Archicembalo, which is described in detail in the last book of Vicentino's treatise, L'Antica Musica, and it is to this book that we now turn for more precise information concerning these microtonal instruments. Both are provided with 2 keyboards, each containing 3 ranks or orders of keys, placed in removable frames. The Archicembalo is fitted with a total of 132 keys, extending through 3 1/2 octaves. The Arciorgano, on the other hand, contains only 126 keys with no indication given as to which ones are omitted. Example 1 shows the disposition of the 6 orders of keys within the frame work of the 2 keyboards. To facilitate the reading of this keyboard, the octave from f-F will be given in descending order with Vicentino's notation and denomination. *5 (Example 2)

The descending octave has been used because it shows more clearly the progression from one order to the next. The names of each of the notes in the succeeding orders are derived from

example 2

F fa ut primo
F fa ut secondo in terzo ordine
F fa ut terzo in quarto ordine
E la mi primo
E la mi secondo
E la mi terzo
E la mi quarto
E la mi quinto
E la mi sesto
D la sol re primo
D la sol re secondo
D la sol re terzo
D la sol re quarto
D la sol re quinto
D la sol re sesto
C sol fa ut primo
C sol fa ut secondo in terzo ordine
C sol fa ut terzo in quarto ordine
B fa b mi primo
B fa b mi secondo
B fa b mi terzo
B fa b mi quarto
B fa b mi quinto
B fa b mi sesto
A la mi re primo
A la mi re secondo
A la mi re terzo
A la mi re quarto
A la mi re quinto
A la mi re sesto
G sol re ut primo
G sol re ut secondo
G sol re ut terzo
G sol re ut quarto
G sol re ut quinto
G sol re ut sesto

the name of the note in the first order that served as their point of origin. This sometimes causes a contradiction between the name of the note and its notation. For instance, A la mi re secondo is notated as G♯. Vicentino is aware of this difficulty since he admits that his A la mi re secondo is commonly called G sol re ut sustentato, and that G sol re ut secondo is better known as F fa ut sustentato, but he prefers to think of the location of his notes on the keyboard rather than on the staff. In his opinion, the name A la mi re secondo shows more exactly the descent from A la mi re primo than does the more common designation. *6

Another problem arises in connection with the notes C and F which do not exist in 6 forms as do the others. Their complete identification is given in Example 2, but in practice, a full form such as C sol fa ut secondo in terzo ordine is abbreviated to C sol fa ut terzo if it progresses to the fourth order, or it is called C sol fa ut secondo if it moves from the first order. A similar dichotomy can be seen in the diagram of the keyboard (Example 1) in which F fa ut terzo in quarto ordine is indicated as F^{40} while C sol fa ut terzo in quarto ordine is shown as C^{30}.

The first order is made up entirely of white keys which correspond to those found in most organs, monochords, harpsichords and similar instruments. It is commonly referred to as the diatonic or natural order, although the presence of a minor third or major third within this order would, according to Vicentino's theory, introduce elements of the chromatic and enharmonic genera respectively. *7 The second order contains those black keys most frequently used in 16th-century organs and the general run of keyboard instruments. In modern terms, these would include F♯, G♯, B♭, C♯, and E♭. These tones lie either a major or a minor semitone above the white notes of the diatonic order. *8 The second order is also known as the chromatic order since its use is always indicated by means of accidentals. If it is employed consistently, that is, if only the second rank of keys is played, it may be called the natural chromatic, although it does not often appear in this pure form. More commonly, the notes of this order are mixed with those of the first, resulting in a concomitant transmutation of species of the genera. A whole step, such as F to E♭, or even F♯ to G♯ within this order, is spoken of as a diatonic step in the chromatic order, or referred to simply as a chromatic tone, the word "tone" implying origin in the diatonic species.

Vicentino's terminology becomes rather confusing at this point because he uses the word "chromatic" with two meanings, first in the root sense of pertaining to the chromatic genus, and secondly, as a synonym for accidental. Thus, "accidental" minor third of the chromatic genus and "accidental" major third of the enharmonic genus would be understood better than the "chromatic" minor third and the "chromatic" major third which he proposes. *9

The keys of the second order are split to provide for the third order, which is then completed by the insertion of shortened black keys between the semitones, E-F and B-C. Although Vicentino does not name this order, it seems to be a continuation of the chromatic, which includes the less usual semitones: $G^{\flat}$, $A^{\flat}$, A#, B#, $D^{\flat}$, D#, E#. It is also more restricted than the other orders with respect to transferrals of species from other genera, "since in its steps, one can not give any termination of the imperfect consonances, that is, of any major third and only one minor third."*10 These 3 orders are all contained within the first frame (telare) or keyboard (tastatura).

The second frame begins with the fourth order, which contains the same white keys as the first order, but pitched a minor enharmonic diesis higher. This level of the keyboard is also referred to as the enharmonic order, which, when it is used consistently, is called natural enharmonic. The description of transferred species becomes even more complicated with this enharmonic order than with the chromatic or diatonic. Although the phrase "toni Diatonici Cromatici in Enarmonico ordine"*11 can be translated literally as "chromatic diatonic tones in the enharmonic order," its real meaning is better conveyed as "tones, diatonic in origin, which have been chromaticized, that is, modified by accidentals, so that they can be used within the enharmonic order." Similar circumlocutions would be necessary for the phrases, "gradi, o spetie del genere Cromatico, Cromatici in Enarmonico ordine," that is, the minor third; or "grado o spetie del genere Enarmonico Cromatico, in Enarmonico ordine," that is, the major third.

The fifth order supposedly stands in the same relationship to the fourth as the second to the first. In the latter case, however, both major and minor semitones occur, whereas in the former, only major semitones are found. The third and last rank of keys in the second keyboard is known simply as the sixth order, and resembles the first diatonic order by using plain names, unmodified by accidentals, for its notes. The pitch, however, is a comma above that of the first order.

The tuning of the Archicembalo and Arciorgano unfortunately presents several perplexing problems, especially in connection with the second keyboard. The first two orders are apparently tuned in a kind of mean tone temperament, "according to the use of the other keyboard instruments with the fifths and fourths somewhat shortened, as the good masters do."*12 The amount of tempering is not indicated, but a tuning in which the fifths are tempered by 1/4 syntonic comma comes closest to the 31-division of the octave which is the basis of Vicentino's overall system. *13 However, with the extension of this "common" tuning to the third order of the instrument, a closed system*14 of 19 notes to the octave is temporarily evolved. Both Zarlino and Salinas have described such 19-division systems, but in the former case, the tuning probably involved a temperament of 2/7 comma while the latter shortened the fifths by 1/3 comma. Zarlino himself admitted the 2/7 temperament to be inferior to the 1/4 comma system *16, a factor which may well have militated against its adoption by Vicentino. *17 Salinas's method, on the other hand, affected unfavorably both the fifths and the major thirds. *18 The invention of this system is credited to Salinas who first described it in 1577 in his De Musica Libri VII, much too late for Vicentino to have known it from this source. Nevertheless, Don Nicola seems to have been troubled by the sound of his own thirds and fifths within the first keyboard, because he gives implicit directions for improving these intervals by means of the other orders:

> Another fine convenience will be found in this tuning that when the performer plays in the first order, and not moving the fingers of the hand when stretching the octave, he can move the middle fingers to play the thirds and the fifths [in the fourth order] and in the same orders that he plays the perfect fifths, in those he will find the major thirds, more perfectly than those which we use.*19

The questions raised by this primary tuning are multiplied as the other orders are described. The tuning of the third order proceeds around the cycle of tempered fifths in the following manner: starting with G# in the second order (G#2), the fifth higher moves into the third order on D#3, down an octave and up a fifth to E#3, *20 up a fifth to B#3 and then down another octave. The flatted keys are derived similarly from $E^{b}2$, descending by a fifth to $A^{b}3$, and another fifth to $D^{b}3$, then down an octave and a fifth to $G^{b}3$, ending a fifth lower on B4, which is thus supposedly the same as $C^{b}3$. This concept of enharmonicism in the modern sense of the term would mean that all the notes of the fourth order could be named by their equiva-

lents: G^{bb}, A^{bb}, B^{bb}, C^{b}, D^{bb}, E^{bb}, F^{b}. This is obviously impossible, since Vicentino states precisely that the difference between the first and fourth ranks of keys is equal to 1/2 of the minor semitone, that is, a minor enharmonic diesis.

The whole problem seems to have been avoided by postponing the tuning of the fourth order until that of the fifth had been completed. He begins the tuning of the fifth order with C fa ut secondo in terzo ordine, that is, B#, and seems to progress as before, but his terminology is very unclear and unexplained. The fifth above B#2 is described as Fa fa ut quinto in quinto ordine, which is contradictory to his previous statement that F, because it moves a semitone to E in the natural diatonic order, can only be divided into 3 orders instead of the customary 6. *21 The next fifth leads to another unexplained location on the keyboard, C sol fa quinto, which is then followed by the easily identifiable $A^{b}5$, $E^{b}5$ and $B^{b}5$. It would therefore seem that Fa fa ut quinto represented $G^{b}5$ and C sol fa quinto, $D^{b}5$, the 2 unaccounted-for notes of the fifth order. A B# to a rather high G^{b} may possibly be accepted as a kind of fifth *22, but the amount of tempering does not agree with any of the fifths so far described. On the other hand, if the modern notational representations of a cycle of fifths from B#, that is, double-sharped F, D, G, D and A, are taken into account, the divergence from the given keys of the fifth order seems to be just as great.

Vicentino uses this fifth order to accomplish the tuning of the fourth level of keys. Starting with B fa mi quinto ($B^{b}5$), he moves into the fourth order on F4, and then continues around the circle of fifths to produce the other notes. This at least has the merit of agreeing more or less with the approach to the fourth order from the third in which C^{b} was considered the equivalent of B4. If, however, a double sharp, the last note reached in the cycle of fifths used in tuning the fifth order, is substituted for $B^{b}5$, the fourth order would have to be expressed in terms of double-sharped E and B and triple-sharped F, C, G, D and A, which would again contradict a series supposedly only a minor enharmonic diesis above the pitch of the natural tones of the diatonic order.

The tuning of the sixth order is not given, so that no clarification can be derived from that source. All that is said about this last order is that its pitches are a comma above those of the diatonic, which would mean that this order serves as an intermediate pitch between the first and the fourth orders, since the comma is equivalent to 1/2 the minor enharmonic diesis.

To confuse the issue completely, Vicentino offers a second tuning for his instrument, based on the perfect fifth. The "puzzling doctrine of the perfect fifth," as Barbour calls it*23, states that the last 3 orders can be tuned with the first 3 by means of this interval. In other words, the perfect fifth of any tone in the first order can be found in the fourth order, and the same would be true of the relationship of the second to the fifth orders and the third to the sixth. Unfortunately the distance between these related orders is not the same so that the fifths would not all be of the same size. Moreover, to take only one specific example, the fifth G to D which is "shortened" in the first order, when "perfected" by playing the D in the fourth order, would exceed the size of a real perfect fifth. The only solution is to understand the term "perfect" in a relative sense.

Vicentino has stated that the main purpose of the comma and the diesis was "to aid a consonance."*24 In his discussion of the interval of the third larger than the minor third by an enharmonic diesis, he adds that because of the proximity of this interval to the major third, it assumes the nature of the larger interval rather than the smaller one. *25 If the fifths normally used are all tempered, any increase in their size would bring them closer to the perfect fifth. It seems logical, then, to assume that Vicentino's use of "perfect" for his alternate tuning of the instrument was intended only in a general sense and not as a specific description.

If exactness had been his goal, he would not have added still another method for obtaining the perfect fifths. In Chapter 17 of his book on the Archicembalo which explains the various leaps and steps from G4, Don Nicola states that a note in the first order will find its perfect fifth in the sixth order, if the interval ascends; "and the same sixth order will serve the fourth order to make perfect fifths, when said perfect fifths descend."*26

Perhaps the solution to the puzzle lies in extending to the fifth the concepts of "propinqua" and "propinquissima" that Vicentino used for other intervals, especially the thirds and sixths. The former term involved an increase of a diesis in the size of the interval, so that the "propinqua" of the "common" fifth would be found in the relationship of the first to the fourth orders. The latter term increased the interval size by a comma, so that the "propinquissima" of the tempered fifth would appear between the first and the sixth orders. In both cases, the "shortened" fifth of the usual tuning would be brought closer

to the idea of a "perfect" fifth.

Cerone, speaking of the Archicembalo, comments that this instrument "at first sight frightened any organist, however eminent, to see such a large quantity of strings and also such a large number of semitones."*27 According to the same source, only Luzzasco Luzzaschi could play it well, a fact which he demonstrated by writing some compositions especially intended for performance on this complicated contrivance.*28 It is not to be wondered that, with all the difficulties encountered merely in tuning the instrument, it did not receive the approbation of many 16th-century contemporaries of its inventor.

In Vicentino's opinion, however, the advantages of his microtonal instruments over the common run of those for keyboard were manifold. His Arciorgano could accompany not only the usual pitches found in Western music, but could also accord with the more subtle intonations of Hebrew or Turkish melodies. It could also adjust to the sound of lutes and viols which were tuned according to the modern tempered system.*29 Moreover, should a choir flatten or sharpen its pitch while singing, the organist could intone the new pitch unobtrusively, and by modulating "in a fine manner," lead the choir back to the correct intonation. In his treatise, Vicentino identifies this practice with the transposition that he calls "musica finta" or "false music" and which involves the use of four flats.*30 By means of these accidentals, the organist quickly adjusts the species of his modes so that he does not discord when the chorus flattens the pitch. For example, if the choir is singing in the Dorian mode and happens to lower the pitch one degree, the organist, by the use of the flats of "musica finta," will begin to play a Dorian on C, and thus cover the error of the performers.

Vicentino seems rather concerned lest anyone confuse this music written in four flats with chromaticism:

> One ought not to speak of falsified music but rather of falsified transcription, because [although] the music is notated with four flats which [thus] to the eye seems completely transformed by the notation, to the ears there is no difference to be heard between music written with flats and that without [flats], as I have said above; and lest anyone call this composition chromatic music, we have already explained in the first book what sort of thing chromatic music [really] is, which involves the change that one heard when first there is a tone and then it is transformed into a semitone, and [con-

versely] from a semitone into a tone, with the chromatic species and with the deprivation of progressing by natural steps.*31

One observation in particular made by Vicentino in the circular describing the Arciorgano foreshadows the future in a striking way:

Among the other modes of composing and of playing, there is one of composing a type of music that involves recitation by a solo singer with the instrument, and it will be such music that in it one will hear recited every sort of word or rather lofty speech, accompanied by harmony.*32

This statement, interpreted in the light of L'Antica Musica as a whole, presages many of the innovations of the Seconda pratica. It bears witness to the battle of those original musical spirits of 16th-century Italy who fought for a new and contemporary art, a battle fought with the aid of ancient theory.*33 Those like Doni*34, who criticized him for his misunderstanding of Greek theory, lost sight of the fact that Vicentino's avowed purpose was not to revive ancient music but to interpret it so that it would be "reduced to modern practice." Others, such as Artusi*35, opposed him because their basic conservatism rebelled against the novel and visionary concepts evoked by Don Nicola's imagination Although his experiments led him into paths which took him far afield from the main stream of music, they at least inspired future theorists to find the right road to the future. Perhaps the fairest estimate of his achievement can be summarized in the words of Burney:

He was a practical musician, and appears to have known his business: in his treatise he has explained the difficulties in the Music of this time, with such clearness, as would have been useful to the student, and honourable to himself, if he had not split upon the enharmonic rocks, and chromatic quicksands.*36

notes

1 A copy of this document appears in A. Catelani, Circolare descrittiva l'arciorgano. In: Gazzetta musicale di Milano, IX (1851) 209-210. It was also reprinted and translated into German by J. Wolf, Das Arciorgano des Nicola Vicentino (1561). In: Der deutsche Instrumentenbau, No. 35 (1900) 299-302.

2 "...haveva... alquanti suoi scolari, che in quell mentre ch'egli sonava l'enharmonio imparticolare cantavano quelle tal sorte di musica, dal medesimo composta: la qual musica fece udire per tutte le principali città d'italia, et io in particolare l'udii in diversi tempi et luoghi, più volte." The quotation and translation are taken from C. V. Palisca, The Beginnings of Baroque Music: Its Roots in Sixteenth Century Theory and Polemics. Unpub. diss. (Harvard, 1953) 341-342.

3 Vicentino's activities during the '50's and '60's of the Cinquecento are sparsely documented. He probably left the service of his patron, Cardinal Ippolito II d'Este, in the late '50's. The last paragraph of the description of the Arciorgano serves notice of his availability for a new position. During 1563 and 1564, he filled the post of chapel master at the Cathedral of Vicenza, his native city. Cf. G. Mantese, Storia musicale vicentina (Vicenza, 1956) 47, n. 36, 37. Finally, in a letter written March 25, 1570, he identifies himself as Rector of St. Thomas's, Milan. Cf. B.A. Wallner, Urkunden zu den Musikbestrebungen Herzog Wilhelms V. von Bayern. In: Gedenkboek aangeboden aan Dr. D. F. Scheurleer op zijn 70sten Verjaardag (The Hague, 1925) 370. Presumably his trips "per tutte le principali città d'italia" account for the years otherwise left undocumented.

4 "...che havendo egli voluto trovare ricapito gli era stato di mestiere lasciare da parte l'enharmonio del suo maestro, et attendere ad altro." Palisca, op.cit., p. 342.

5 The dot (.) over a note raises its pitch by a minor enharmonic diesis, the comma(,) by an interval of the same name which is equal to half of the minor enharmonic diesis. The minor enharmonic diesis occurs between the major and minor semitones. Boethius calls this interval a comma, but since Vicentino's semitones do not agree in size with those of the earlier theorist, the new name has become necessary. Cf. N. Vicentino, L'Antica musica ridotta alla moderna prattica (Rome, 1555) f. 17v-18.

6 Ibid., f. 103v-104v.

7 Instead of considering the tetrachord as a unit, Vicentino felt that the use of any one of its component members was sufficient to identify the genus. Thus, chromatic could be represented (1) by the series: minor third, half-step, half-step; (2) by the minor third alone; (3) by a half-step alone. Similarly, the major third alone could be interpreted as evidence for the existence of the enharmonic genus. In essence, then, the music commonly sung was in reality a mixture of the three genera. Ibid., f. 95. This type of interpretation was not limited to Vicentino alone, although he was practically the only theorist to include the enharmonic in his consideration of mixed genera. Bermudo, for example, speaks of a semichromatic genus which combines the diatonic and chromatic: "Quattro generos ay de Musica eneste tiempo, co[n] viene asaber diatonico, Chromatico Enarmonico, y Semichromatico. Este genero Semichromatico, es compuesto de eldiatonico y del chromatico, y es lo ahora tañen y cantan en composicion." Bermudo, Declaración de Instrumentos musicales,

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1555, facs. ed. M. S. Kastner. In: Documenta musicologica, Ser. I, no. XI (Kassel, 1957) f. 22, col. 1. This opinion is repeated in the treatise of a less well-known Spanish theorist, Martin de Tapia: "No ay hombre que no alabe (y con gran razon) la musica de este tiempo, y es mezclade de el genero Diathonico y Chromatico." Tapia, Vergel de musica (Burgo de Osma, 1570) f. 44v. Morley similarly remarks that the "kind of music which is usual nowadays is not fully and in every respect the ancient Diatonicum... so that it must needs follow that it is neither just Diatonicum nor right Chromaticum." T. Morley, A Plain and Easy Introduction to Practical Music, ed. R. A. Harman (London, 1952) 103. He continues with the observation that a point used by organists, consisting of the notes E, F, F♯, G, G♯, A, is not right Chromatica, but a bastard point patched up of half Chromatic and half Diatonic. Lastly it appeareth... that those virginals which our unlearned musicians call Chromatica ... be not right Chromatica but half Enharmonica." Ibid.

8 Vicentino suggests an easy way to remember the notation of these semitones. The minor semitone is smaller than the major, hence will lie nearer to its point of origin, that is, either on the same line or space, e.g., F to F♯, A to A^{b}. The major semitone, as the larger interval, will be located further away, that is, on an adjacent line or space, e.g., A to B^{b}, G to F♯.

9 Ibid., f. 101v.

10 "...perche ne i gradi di quello, non si puo dare termine alcuno delle consonanze imperfette, cioè d'alcuna terza maggiore, & sola da una minore." Ibid. There is no reason, however, for not considering the whole steps as accidental tones derived from the diatonic genus.

11 Ibid.

12 "...secondo l'uso de gli altri stromenti con le quinte & quarte alquanto spontate, secondo che fanno li buoni Maestri." Ibid., f. 103v.

13 J. M. Barbour, Tuning and Temperament (East Lansing, Michigan, 1953) 37.

14 "... a regular temperament in which the initial note is eventually reached again." Ibid., p. ix. In the situation here under discussion, the C of the first order is closed with the B♯ of the third order.

15 Ibid., p. 30, 34.

16 Ibid., p. 33.

17 That Zarlino published his Istitutioni armoniche in 1558, does not mean that Vicentino could not have known the 2/7 comma temperament, because the instrument which contained that tuning had been built at Zarlino's behest as long before as 1548, by Maestro Dominico Pesarese. D. H. Boalch, Makers of the Harpsichord and Clavichord 1440 to 1840 (London, 1956) 24, col. 1.

18 Barbour, op. cit., p. 33-34.

19 "...un'altra bella commodità si ritroverà in questo accordo che quando il sonatore sonerà nel primo ordine, & non movendo li deti della Mano quando farà ottava potra muovere i deti di mezzo, che toccheranno le terze & le quinte & nelli medesimi ordini, che toccerà le quinte perfette in quelli si ritroverà anchor le terze maggiori, piu perfettamente accordate che quelle, che noi usano." Vicentino, op. cit., f. 104v.

notes

20 Erroneously given as E la mi terzo instead of F fa ut secondo in terzo ordine. Ibid., f. 103v.

21 Ibid., f. 104.

22 Just such an accidental fifth is given by Vicentino as the penultimate example of a series of leaps of the fifth. Ibid., f. 145v.

23 Barbour, op. cit., p. 118.

24 "...peraiutare una consonanza." Vicentino, op. cit., f. 18.

25 Ibid., f. 21v-22.

26 "... & il medesimo sesto ordine servirà al quarto ordine à far le quinte perfette, quando discenderà dette quinte perfette." Ibid., f. 109v.

27 "... por la primera vez espanta à qualquiera eminente Organista, por ver ten grande cantidad de cuerdos, y tambien un tan gran numero de semitonos." P. Cerone, El Melopeo y maestro (Naples, 1613) f. 1041.

28 Ibid. These works have been lost according to O. Kindeldey, Luzzasco Luzzaschi's solo-Madrigale mit Klavier-Begleitung. In: Sammelbände der internationalen Musikgesellschaft, IX (1908) 562.

29 Both lutes and viols were tuned in equal temperament, "con la divisione de i semitoni pari." These equal semitones cause errors when playing with other instruments, whose semitones are unequal. But the Archicembalo and the Arciorgano can correct these defects because of the microtonal divisions. Vicentino, op. cit., f. 146v.

30 From our viewpoint, only three flats are actually employed. The E^b is notated both in its high and low positions on the staff and is thus counted twice. Later examples of "musica finta" vary from two to four in the number of flats, but always involve a transposition down a tone. Cf. Ibid., f. 46v-47v, 50-50v. There are no examples of "musica finta" given in which a sharpened pitch is corrected.

31 "...non si dè dire musica finta, ma più presto transcrittione finta, perche la Musica è notata con Quattro b. molli, che alla vista, pare tutta tramutata p[er] lo notare, & à gl'orecchi nissuna differenza si sentirà dalla Musica scritti con b. molli, à quella scritta senza come di sopra hò detto, & accio che alcuno no[n] dica Musica Cromatica à quella compositione che sarà notata con quattro b. molli, noi già nel primo libro haviamo dichiarato che cosa sia Musica Cromatica, laquale sarà la tramutatione che si sentirà quando prima serà [!] tono, poi che si tramuterà in semitono, & di semitono in tono, con le spetie Cromatiche & con la privatione del caminare per i gradi naturali." Ibid., f. 47v.

32 See supra, p. 4.

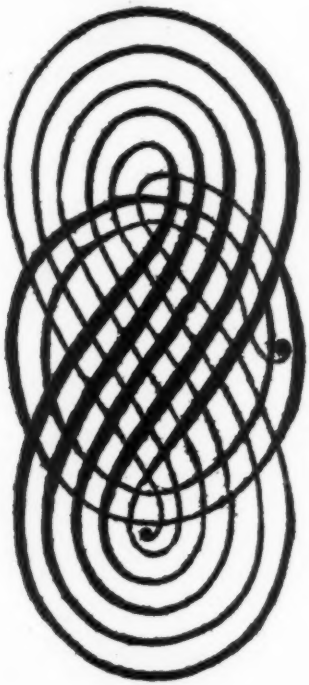
33 H. Zenck, Nicola Vicentinos L'Antica musica (1555). In: Theodore Kroyer-Festschrift (Regensburg, 1933) 87.

34 See especially G. B. Doni, De praestantia musicae veteris libri tres (Florence, 1647) 22, where he states that Vicentino and his imitators would not have fallen into error had they understood the writings of Aristoxenus and others: "Quem in errorem delapsi profecto non essent, si antiquas illas germanasque harmonias ex Aristoxeni, aliorumque scriptis, percepissent."

notes

35 In his discussion of the debate between Vicentino and Lusitano, Artusi states categorically that he sides with the latter: "In questa parte [that is, whether music is purely diatonic or a mixture of the three genera] io tengo col Lusitano." G. M. Artusi, L'Artusi overo delle imperfettione della moderna musica ragionamenti (Venice, 1600) f. 38. The very title of this work bespeaks Artusi's innate conservatism.

36 C. Burney, A General History of Music from the Earliest Ages to the Present Period (London, 1776–1789) III, 162.



54

Register and the Large-Scale Connection

By

In an essay, Vom Organischen der Sonatenform, published in Das Meisterwerk in der Musik, v. 2, 1926, Heinrich Schenker writes:

In the first movement of the Piano Sonata, Op. 109, Beethoven establishes the following high points in the development section:

m. 21 42

ERNST OSTER

After reaching the high g#3 he suddenly abandons it and leaps down to d#2. What is the meaning of this perplexing leap? Even if we were finally to have recognized a relation between these two widely separated climaxes ... we still would not have gained the ultimate clarity. The latter is provided by the following relations:

Schenker goes on to say that Beethoven pursues these two tones also in the development section and in the coda. To the master, they have the meaning of an actual motive and are "a clue to a world of unity and coherence."

This feature of the first movement of Op. 109 demonstrates in brief the topic of our discussion. Two tones which, viewed superficially, have nothing to do with each other enter into a relationship merely through the register in which they appear. In this case register becomes one of the main elements of composition and is on an equal footing with harmony, counterpoint and thematic development. The consideration of register is indispensable to the true understanding of the main feature of this development, namely the preparation of the first two tones of the recapitulation in the three-line octave.

It is surprising that Schenker was the first to draw attention to the significance of register in composition. As far as is known to me, the only other reference to registral significance was made by Schenker's pupil, Oswald Jonas, in his book, Das Wesen des musikalischen Kunstwerks, published in Vienna, 1934.

Schenker, in Der freie Satz, published in Vienna, 1935 and 1956, devotes a chapter (sec. 268-270) to what he calls "obligate Lage" (Obligatory Register). By this is meant that the fundamental line as well as the bass appear in a single and primary register which is maintained through the composition, despite frequent necessary excursions to higher or lower octaves. A magnificent confirmation of this view is to be found in the C major and C minor Preludes of the first volume of the Well-Tempered Clavier. These Preludes first appear in Friedemann Bach's Clavierbüchlein, although in a shorter version. In this earlier version, after beginning in the two-line octave, they both end in the one-line octave. When Bach incorporated these Preludes into the Well-Tempered Clavier, he lengthened them and made little improvements here and there. In addition, he apparently felt that it was necessary or at least desirable to return to the initial register at the end of each composition. One can easily see at which points in the added sections Bach regained the higher octave, thus fulfilling the "law of Obligatory Register." A detailed analysis of the C major Prelude appeared in Schenker's Fünf Urlinie-Tafeln, published in Vienna, 1932. While an analysis of the C minor Prelude appeared in his essay, Das Organische der Fuge, published in Das Meisterwerk in der Musik, v. 2, 1926. Excerpts from both are included in Der freie Satz.

Strangely enough, Forkel considered these shorter versions to be improvements made on the ones appearing in the Well-Tempered Clavier. And more recently, Siegfried Borris, in an essay, Das Bearbeitungsverfahren bei den 11 Präludien im Friedemann-Bach-Buch, published in Die Musikforschung, Jahrg. V, 1952, has tried to show that the shorter versions in the Friedemann Bach Clavierbüchlein were arrangements of the ones in the Well-Tempered Clavier, made by Bach himself to adapt them for the little hands of his son. Among other things, this argumentation disregards entirely the question of register which is of paramount importance in judging the relative value of the different versions.

It is not the purpose of this article to go further into the question of Obligatory Register in its broadest aspect as it pertains to an entire composition. Our aim is rather to show a number of instances where register contributes in an essential way to clarifying certain contrapuntal, structural, or thematic-motivic connections and relations. It is not intended to show the historical development of the use of register for artistic purposes. Our approach must necessarily be more or less unsystematic, and we will simply proceed from one example to the next.

Before presenting examples in which the bass shows large-scale progressions, we should like to discuss one of the relatively rare cases in which a middle register plays an essential role. In the middle section of the Adagio of Mozart's Piano Sonata, K. 576, in D major, the main melody notes are doubtless a2, b2, a2 in m. 17, 18, and 19 respectively. Yet if we follow up the initial c#2 of m. 17 we hear that it describes a slow turn-like motion c#2-d2-c#2-b#2-c#2 during these measures. In Example 1a (p. 58) these notes are connected by heavy lines between the staves. Since c#2 is also the very first tone of the Adagio and since it reappears in m. 5 and in m. 13 we understand the c#2 of m. 17 simply as another occurrence. Of course there is nothing remarkable about a middle section beginning with the same tone as the main section. Numerous instances of this are to be found, for example, in Chopin's Mazurkas Op. 24/4 or Op. 30/1, taken at random. What gives the c#2 in our Mozart excerpt such significance is the fact that both in m. 1 and in m. 17 it is followed by a turn, the second one enlarged, adapted to F# minor, and hidden under the higher melody tones. It permeates the first 4 measures, thus relating and linking the F# minor part closely to the beginning. The point we want to make here is that despite the motivic relationship of the turn which can easily be seen on paper, this

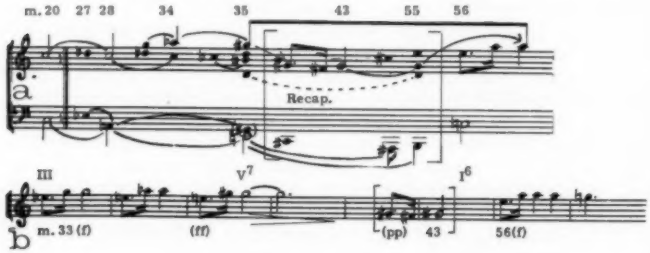
example

1

Mozart: Sonata in D major, K. 576.

7

Schubert: Quartet in A minor.



relationship is perceivable only through the identity of register.

Further, Example 1a (p. 58) shows that in m. 23 the turn starts on d2 (note the suspension of d2 on the third beat which corresponds to the suspension of c#2 in m. 19!) and that it "comes out into the open" in 32nd notes at m. 24. Example 1b (p. 58) shows that the entire middle section is governed by the same turn, with b#-c# appearing an octave lower, for pianistic reasons. Significantly, Mozart does not write a turn in m. 39 — although it would have been due here — a turn based on f# instead of c#2 or its auxiliary note d2. However, he makes amends for this missing turn. At the very last moment before the return of the main section, he manages to insert c#2-b#2 between the seventh d and its resolution c#2 in the reprise so that at this point we hear once more the turn motive (Example 1c, p. 58). Since we already are on the V^7 chord of A major and expect the tonic momentarily, the turn with its b# sounds like a last farewell to the events of the middle section. In the subsequent measure it is replaced by the turn with the initial, normative b♮.

Two more instances in which the middle register plays a leading role are to be found in Brahms' Intermezzo, Op. 116/4, in E major, and in the Scherzo of Beethoven's Sonata, Op. 26, in A^b major. In the Brahms work, the idea appearing in m. 1 is continued to d#1 at the pianissimo, 3 lines before the end, and from there to e1, 9 measures away.

Beethoven's Scherzo opens in an unusual way.

Example 2. Beethoven: Sonata in A^b major, Op. 26

The top voice outlines the A^b triad but the bass enters on f1, the auxiliary note of e^b1 in m. 2. Later this f1-e^b1 becomes the first motive of the Trio. Although the F minor triad in m. 1 is of a merely contrapuntal nature, Beethoven nevertheless begins the reprise (m. 45) as if the piece were actually written in F minor, introducing it by a V^7 harmony on C which lasts no less than 21 measures. Thus, f1, which in m. 1 clashes so sharply with the tonic triad outlined by the top voice (see the sforzato), determines the entire course of the compo-

sition. Because f1-e^{b}1 is of such pre-eminent importance we can understand the beginning of the Trio as a reiteration of m. 1-2 of the Scherzo. It is as if f1 at last comes into its own when it becomes the third in D^{b} major. In passing, it should be mentioned that f1-e^{b}1 played a certain role even in the first movement, especially in the middle section of the theme and at the beginning of the last variation.

As an example of bass progressions which are made to stand out by means of low register we cite m. 52-124 in the first movement of Bach's Italian Concerto.

Example 3. J.S. Bach: Italian Concerto.

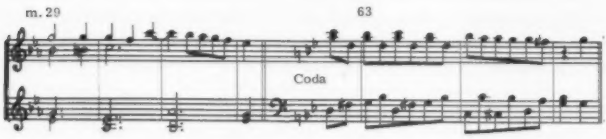
It is noteworthy that Bach's keyboard extended as far as the low A (see the Finale); thus he could have written B^{b} and A in m. 60 and in m. 74 an octave lower, had he so desired. Yet he reserved this register for the main structural tones C-D-B^{b}-C, of which C-B^{b}-A is only a prolongational motion.

Bass progressions brought into prominence in a manner similar to that described above occur fairly frequently. For example, in Chopin's Etude, Op. 10/8, in F major, the bass line D-C-B^{b}-A (m. 29-41) stands out because of the register. Domenico Scarlatti was particularly ingenious in using the extreme registers — especially the low bass — very sparingly, and chiefly at the main structural points. Examples of this as well as examples of the use of register for other purposes can be found in abundance in his Sonatas. When one examines the Sonatas for features of this kind one gradually comes to realize that the beauty of Scarlatti's keyboard style — and that of other composers too — is at least partly due to masterly treatment of register.

Turning now to registral features of the top voice, we should first like to mention Beethoven's Bagatelle, Op. 119/1, in G minor, and its coda in particular. A coda was probably necessary in this piece, perhaps because it needed a stronger ending after the almost literal repetition of the first section. But what would be the tonal content of the coda? The E^{b} major middle section starts out from g1, gradually works its way up to g2, then ends as shown in Example 4, with c3 and b^{b}2 super-

imposed above the descent g2-f2-e^{b}2.

Example 4. Beethoven: Bagatelle in G minor, Op. 119/1.



The superimposed c3 and b^{b}2 are touched upon only once, and our desire for their continuation — perhaps as in m. 19-20, where we heard the same situation an octave lower — remains unsatisfied. But the desire is satisfied in the coda. By means of a long ascent, c3 and b^{b}2 are reached again. This time they are led down stepwise to g2, in a stronger, more definite fashion and supported by cadential bass steps. Thus, here the high register which was only briefly suggested previously is restated, and that which was lacking in the middle section is finally fulfilled. But although the two points in question, the one in the middle section and the other in the coda, have been associated by means of register, they are not structurally connected. The c3 and the passage that follows in the coda are merely a repetition of something we have heard before, the repetition of a musical idea even though its meaning is changed. Thus the association is necessarily loose and was possible only in a composition as simple in character as this Bagatelle.

In contrast to the situation described above, the registral connection between m. 17 and m. 20 of Bach's Chromatic Phantasy is very close.

Example 5. J.S. Bach: Chromatic Phantasy.

If we eliminate the arpeggiations and two subsidiary chords, we reveal the auxiliary note motion, 9-8, over A. This is perhaps so obvious that one need not call special attention to it. However, we wish to emphasize that the principle is exactly the same whether we deal with a group of 4 measures or with connections over much larger spans such as those to be examined below: register is the chief element which makes

the two points in question stand out and thus be related and connected.

The excerpts from Brahms' Capriccio, Op. 116/7, in D minor, presented in Example 6 do not require comment.

Example 6. Brahms: Capriccio in D minor, Op. 116/7.

The parentheses indicate that in the intervening measures the lower register is prevalent. There is marked similarity between this type of piano style, with the high register appearing at only a few strategic points, and that of Scarlatti. Through the ages the external appearance of music had changed immensely, of course, but the principle of writing for keyboard instruments remained the same.

The Menuetto of Schubert's Quartet in A minor, specifically its recapitulation, is probably unique in the entire literature (Example 7a, p. 58). Upon arriving at the V^7 chord in m. 35, there is a sudden halt, followed by a recapitulation based on C♯ minor instead of in the expected A minor, with the register dropping a full octave. (Actually, C♯ on which the recapitulation begins is merely a connective between E and A♯ which lies within a prolongation of the dominant extending from m. 35 to m. 55.) Furthermore, the motives shown in Example 7b (p. 58) are also continued at this point and the previous forte is resumed. All these factors contribute to the linking of m. 35 with m. 56, but probably the most obvious factor involved is the abandonment and resumption of the high register at m. 35 and at m. 56, respectively. The beginning of the recapitulation is interpolated between these two points. It is subordinate to larger events of a higher order, or, to use an image, an arch is formed over it by the main progression shown in Example 7a (p. 58) and specifically by g♯2-a2. One might almost describe it as having been composed in a parenthetical manner. To be sure, the C♯ minor recapitulation is thematically important and does initiate the third section of the composition. However, its importance is minimized by the other events which bypass it. In consequence of all this the middle

and the third sections are closely linked together, much more so than would have been the case if the recapitulation had started in a normal manner. This bypassing of an otherwise important event by means of registral connections can be found occasionally in the works of the great masters. Wherever it occurs, it constitutes one of the most remarkable features of the particular composition.

In the Brahms Capriccio in D minor (Example 6, p. 62) the return of the first section in m. 62 is inserted or interpolated in a manner similar to that described above. And in the Rondo of Mozart's Violin Sonata, K. 526, in A major, the tenth a-c♯3 in m. 183 (note the beautiful slur!) is derived from and continues the diminished fifth g♯1-d3 outlined in the ending of the previous E major section (m. 161-164).

Example 8. Mozart: Violin Sonata in A major, K. 526.

Thus the intervening recurrence of the main rondo theme in the lower register sounds incidental to this large-scale linkage of the E major section with the one starting at m. 183. Here again we have a link that is perceivable only through the abandonment and resumption of the three-line octave. It should perhaps be mentioned that, of course, the diminished fifth has resolved to a-c♯ in the A major section of m. 167 — but in the lower octave. As far as register is concerned — and this is what matters here — d3 is continued to its tone of resolution only in m. 183.

After having followed the previous examples, a longer passage from the Finale of Mendelssohn's Quartet in E minor will be easily understood (Example 9a, p. 65). Measures 288-331 all lie within the one-line octave. In m. 332, the e2 of m. 287 continues to d♯2. It is preceded by e2 which joins together the two separated measures. Thus the half note e represents a huge suspension spanning 45 measures (Example 9b, p. 65). And 5 measures later when d♯2 returns to e2, the notes marked by a bracket show a slightly changed enlargement of the motive appearing in m. 286-287, the point at which the high register was interrupted. Thus these two distant points are closely linked together, primarily by means of register, and, in addition, by contrapuntal means (suspension) and motivic relation.

By-passing of the kind described was occasionally used by Bach even in fugue writing. Measures 6 - 8 of the Fugue in C minor from Book 2 of the Well-Tempered Clavier which we quote in Example 10a (p. 65) are of particular interest in this regard. According to Schenker, in Der Tonwille, Heft 3, p. 43, published in Vienna, 1923, Beethoven made a copy of this Fugue for himself and marked the B in m. 7 with a large cross. Schenker remarks that this B contains a most significant clue to organic fugue writing and that at the same time it points up an essential difference between the fugal art of Bach and the fugue writing of others. We quote:

> Although this fourth entrance, obviously in comes form, should normally appear in G minor, Bach deprives it of this key by altering B^{b} chromatically, thus incorporating it into the main key of C minor. Of course, Bach did this not in order to be different, but because he wished to fulfill the over-all tonality also in fugue writing.... Beethoven noticed this particular detail; it and similar features are the reason why Beethoven studied and emulated Bach.

Thus far Schenker. A detailed analysis of the fourth entrance and its immediate surroundings reveals this passage to be even more remarkable. Example 10b (p. 65) shows the main voice-leading progressions, with the notes written in the registers in which they actually appear and with a few implied notes in parentheses; Example 10c (p. 65) presents a further reduction with the various registers disregarded. It becomes apparent that up to and including the second beat of m. 8 we hear a progression of parallel tenths between bass and top voice. Consequently, the beginning of the fourth subject entrance (m. 7) occurs at the second tenth e^{b}-g which is merely passing through. We even have to hear an E^{b} triad at the beginning of this measure. As to the top voice, the discontinuation of the high register and its resumption in m. 8 show clearly that the first tenth f-$a^{b}2$ finds its real continuation only with E^{b}-g2 on the third beat of m. 8, well after the fifth entrance has begun. The true goal of the over-all motion is therefore the C minor sixth chord in m. 8, not the C minor triad in m. 7. Because of this the fourth entrance is weakened in three different ways: the B deprives it of the G minor quality, the key in which it should have appeared; it is merely inserted between several passing tenths; and the registral connection of the top voice makes it sound almost parenthetical. We wait for the continuation of $a^{b}2$, and when g2 finally appears as its continuation, the fourth entrance is a thing of the past. This passage is a striking example of Bach's art of subordinating fugal entrances to the broader scheme of the

example

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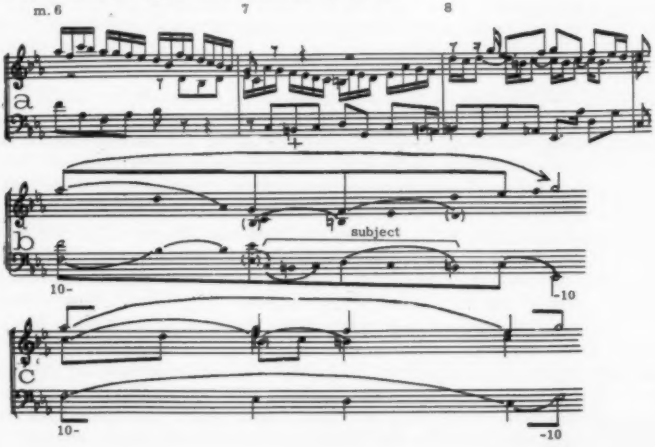
Mendelssohn: Quartet in E minor.

10

J. S. Bach: Fugue in C minor, WTC II.



composition and to make them an integral part of the whole. To achieve this end, he often made the entrances so inconspicuous that they pass by almost unnoticed. A good example of this is the entrance in m. 11 of the same fugue, although Bach uses means other than registral to achieve this. Other instances of Bach's use of register can be found in the Fugue in C# major, from Book 1 of the Well-Tempered Clavier, m. 13-16 and in the big Organ Fugue (BWV 547) in C major which is altogether a miracle of this type of fugue writing. One is reminded of Robert Schumann's somewhat facetious remark:

> The best fugue will always be that which the public takes for a Strauss Waltz; in other words, where the artistic technicalities are covered as are the roots of a flower, permitting us to see the blossom only. I know of — the case is real — a connoisseur of music, by no means contemptible, who mistook a Bach Fugue for a Chopin Etude — to the honor of both.

As additional examples, we refer the reader to m. 21-41 of the first movement of Mozart's Piano Sonata in C minor, where the first part of the E^b major section is "bridged over." We also suggest m. 14-23-27 of the first movement of Mozart's Quartet in D minor, which are somewhat similarly constructed, or m. 83-108-120-132 of Schubert's Wanderer Phantasy, where the beginning of the E^b major theme is inserted between a^b3 and a^b3-g3 in m. 108 and in m. 120. Lack of space makes it impossible to go into detailed analyses of these compositions. They would reveal beautiful motivic and other relationships and connections besides the ones expressed solely by register. A few more interesting examples can also be found in Jonas' book, published in Vienna, 1934, Das Wesen des musikalischen Kunstwerks, Ex. 116, 118, 119, 194; and in Schenker's Der freie Satz, Ex. 40, 7; 62, 3; 62, 4; 101, 6.

One might well ask why in the course of this discussion no examples from orchestral compositions were cited. The reply is that in orchestral compositions register plays a less significant role in pointing out or providing large-scale connections, than it does in keyboard compositions. The reason may be that the orchestra, with such a great variety of means at its disposal, does not require the use of register to the same extent as the more poorly endowed keyboard instrument. A similar reason may account for the lack of examples from such an outstanding composer as Chopin. His richly developed piano style apparently found new techniques of writing which probably replaced older ones. Besides, one may say that from the very beginning of any of his major compositions all the registers of the keyboard are simultaneously present, as it

were. Even so, register connections and relations are to be found in his compositions. In many cases, however, they are not quite as clear-cut as the ones in earlier piano music and were therefore not as suitable for the first presentation of the subject.

As the last example to be presented we have chosen the first movement of Beethoven's Piano Sonata, Op. 13, in C minor, the Sonate Pathétique. Clearly, this movement extends in various ways far beyond anything the young Beethoven or anyone else had written before. One of the most striking features of this magnificent piece of music is the reappearance of a part of the introduction at the beginning of the development section, and again at the beginning of the short coda. A similar use of the introduction within the Allegro section is to be found in Haydn's Symphony in E^b major, No. 103, which Beethoven probably knew at the time he wrote his Sonata in C minor. Beethoven had employed a similar procedure once before: in the Kurfürsten Sonata in F minor, written at the age of 12, he introduced the recapitulation by a free repetition of the initial introduction. In Op. 13, his intention was different: to make the introduction an integral part of the entire first movement. The combination of elements of the first subject and of the introduction at the beginning of the Allegro in the development (m. 137-141) serves the same purpose. Also the melodic relationship between certain elements of the introduction and certain passages of the Allegro is quite apparent and has been described repeatedly. Thus as far as thematic material is concerned the composition is a unified whole.

When we turn to an examination of the structure of the exposition, we will first of all have to clarify the harmonic and contrapuntal meaning of m. 51-88. There can be no doubt that this section is to be considered the second subject. This is because when we arrive at E^b major, III of C minor, (m. 89) we have the impression of already being at the beginning of the coda of the exposition. This impression is created mainly by the fact that the ascending chromatic line of m. 89-98 bears a resemblance to the first subject. The resemblance becomes still closer in the analogous place in the recapitulation (at m. 253).

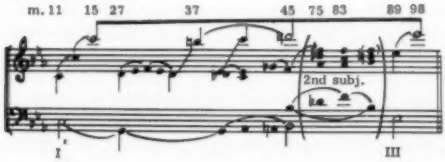
It is surprising that even Tovey considers the second subject to be written "in E^b minor." By no means can the six-four chord at its beginning be considered an inversion of an E^b minor triad. Nor is there any E^b minor triad or sixth chord to be found, except for one in m. 79. This, however, is merely

a passing harmony between D^b and F in m. 75 and in m. 83. The second subject should be understood as taking place within an extended prolongation of the B^b harmony, the dominant of III which finally enters at m. 89.

Example 11a

The bass, represented in Example 11a, shows an arpeggiation of the B^b minor instead of the B^b major harmony, the minor third D^b appearing in m. 75. Thus it becomes evident that the initial "E^b minor" six-four chord has nothing to do with E^b minor; rather, it is related to the D^b chord arising in m. 75, and this in turn is part of the larger B^b minor harmony. The g^b1 is an auxiliary note of f1 in m. 43 and serves as consonant preparation of the seventh g^b in m. 64. It then returns to f as shown in Example 11a. This makes it clear that the first E^b harmony is reached only after the second subject has passed by: in m. 89, at the beginning of the coda of the exposition. Instead of bringing in the second subject on III, which is the normal procedure, Beethoven starts it on B^b, that is, during the motion towards E^b. The purpose of this overlap of structural and thematic events is to achieve a tighter connection between the different sections. In an earlier work, Sonata, Op. 2/1, in F minor, Beethoven had based the second subject on the dominant of III. However, the prolongation of that dominant was simpler and briefer than the instance in Op. 13. Turning now to the function of register in this remarkable treatment of theme and harmonic progression, we see with the aid of Example 11b, that the main bass progression from the beginning of the exposition to the beginning of the coda consists of C-B^b-E^b.

Example 11b



Note against note, above this bass progression, the top voice moves from c3 in m. 15 to d3 in m. 45, and finally to $e^{b}3$ in m. 98. This ascending third in the upper voice thus spans the entire exposition, unfolding in a single register. In relation to it the second subject is an interpolation, an episode between the passing tone d3 and its goal $e^{b}3$. Truly, a greater triumph in the use of register for large-scale connections could hardly be imagined.

In addition it must be remarked that the rising third c-d-e^{b} represents more than just the lower third of the C minor triad: it is thematic in character, constituting a huge enlargement of the same third in m. 1 of the introduction. The introduction itself shows a first enlargement of this third, with the same bass as later in the Allegro, in the one-line octave in m. 1, 4 (end), and 5. This enlargement then prepares the ground, so to speak, for the second and most extended enlargement in the exposition.

In the recapitulation, it was not possible for Beethoven to duplicate the effect he had created with his treatment of the second subject in the exposition. Obviously he could not base it on the dominant, G, and begin it with a six-four chord on this tone. To provide at least some harmonic contrast and achieve an effect similar to the suspense created by the B^{b} harmony in the exposition, he begins the second subject on the F minor six-four chord, the subdominant (m. 221), which then leads to V and to I. This six-four chord is, for once, a true inversion since it is followed by the F minor sixth chord.

This was a satisfactory solution for matching the harmonic appearance of the second subject in the exposition. But how could an equivalent be found for the bypassing of the second subject by means of the high register? Since the recapitulation begins and ends in C minor — not, as does the exposition, on different harmonies, this was impossible. But Beethoven found a "substitute solution," one which is as impressive as his use of register in the exposition. We find that the development section concludes in m. 187 with a V^{7} chord. The resolution of the seventh f3 to $e^{b}3$ seems not to be forthcoming. The recapitulation begins, the entire first subject passes by, still no $e^{b}3$. The second subject begins on the subdominant, as described above; then in m. 231-232 the melody leaps, unexpectedly and strikingly, to f3. This f3 takes up the preceding, unresolved, f3 of the development; it becomes a seventh over the following dominant and finally resolves to $e^{b}3$ in m. 239, in the tonic six-four chord. This is the "substitute solu-

tion": Instead of bypassing the second subject with the high register so that it would sound parenthetical, the beginning of the recapitulation itself is bypassed and appears incidental to the progression V^7 - I^3 (f3-$e^{\flat}3$), which extends far into the second subject. In the Menuetto of his Quartet in A minor, Schubert carried out the same idea but by different means, as previously discussed and illustrated in Example 8 (p. 63).

Example 12a

Example 12a shows Beethoven's general plan (an octave lower) and explains also why the six-four chord in m. 239 must be considered a tonic six-four, not an embellishing chord of any kind.

Example 12b

Example 12b includes f3 of the second subject. This note appears first as a consonant sixth which prepares and reintroduces the seventh f3. One can hardly consider it as structurally, contrapuntally connected back to f3 of the development. Rather, f3 forms what one might describe as a prefix to $e^{\flat}3$. It is associative in character, reiterating f3 of m. 187 for the purpose of underscoring the large progression f3 - $e^{\flat}3$.

In a looser way even the introduction of Op. 13 is connected to the Allegro by means of the high register. Its climax is also a V^7 chord with f3. This f3 does continue to an $e^{\flat}3$, but since $e^{\flat}3$ appears in a six-four chord on the dominant, it is a passing tone moving on to d2 in the next measure, not a true resolution. In the strictest sense, then, f3 resolves in the three-line octave only at m. 98, towards the end of the exposition. This huge arch subordinates the first and second subjects of the exposition, just as f3 of the development section moves to $e^{\flat}3$ of the second subject and bridges everything in between.

Example 13

But even if we wanted to attach more importance to $e^{b}3$ in m. 10 — it certainly gives more definition to the ending of the introduction than is found at the end of the development section — the fact would remain that the three-line octave is abandoned at this point, that no d3 as the tone of resolution appears, and that $e^{b}3$ is taken up only in m. 98. Consequently, the picture drawn in Example 13 would not be essentially altered. Corroborating our reading is the striking resemblance of m. 9 - 11 to m. 187 - 195, with passages rushing down to the beginning of the first subject.

One can safely say that the grandiose use of the high register for creating large-scale connections and for tying various sections closely together constitutes one of the main features of this movement. If we compare this movement to later compositions of Beethoven it is fair to say that it equals them in scope as far as the use of register is concerned. In other respects, such as complexity of content or subtlety of expression, Beethoven's later compositions probably surpass the Sonate Pathétique.

In closing we point out that the purpose of this article has been to indicate the important role which register can play in establishing the larger connections in a musical composition. We have seen that in some works, particularly in piano works, register assumes a significance as great as that of harmonic and contrapuntal texture or the unfoldment of thematic-motivic relationships. Its importance as one of the structural elements of music should not be overlooked in composition and analysis.

Set Structure as a Compositional Determinant

By

I propose, in this article, further to explain and expand certain observations made in a previous article†, and to extend the investigation of the principles of set formation and transformation which was begun in another article††. In this latter paper I was concerned primarily with those set properties — pitch class and intervallic, order-preserving and merely combinational — and those relationships between and among forms of the set which are preserved under the operations of the system, and which — in general — are independent of the singular

† "Some Aspects of Twelve-Tone Composition." The Score and I.M.A. Magazine, 12 (1955). Henceforth abbreviated: SA.

†† "Twelve-Tone Invariants as Compositional Determinants." The Musical Quarterly, XLVI (1960). Henceforth abbreviated: TT.

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structure of a specific set. Here, to the end of discovering certain compositional consequences of set structure, the concern will be with those attributes of set structure which maintain under the systematic operations only by virtue of the particular nature of a set, or of the class of sets of which it is an instance, together with a particular choice of operations.

Much of the discussion will be motivated by and centered about the initial measures (Example 1) of the third movement of the Schoenberg Fourth Quartet, the object of the observations mentioned above, not only — or even primarily — for the purpose of analyzing this excerpt, but in order to infer similar and further extensions of the properties and methods it exhibits. Many of these properties are what I have termed "combinational," to the extent that they are associated with

collections of pitch classes within the set distinguished by pitch or intervallic content alone, and not necessarily by ordering, so that under the operations of the system, this collection remains fixed with regard to such content but not necessarily — or usually — in terms of internal ordering or order placement of the collection within the set.

The, by now, most familiar property of this kind embodied in the set of the Fourth Quartet is that of hexachordal combinatoriality, or, more precisely, hexachordal inversional combinatoriality, as a result of which any one of the two disjunct hexachords of any of the, at most, 48 set forms can be associated with the order corresponding hexachord of one or more inversions of that set form transposed by an interval or intervals determined by the pitch class ordering of the pitch classes within the hexachord, so that each such pair of hexachords contains all twelve pitch classes. This is equivalent to stating that a set is so constructed that the content of one of its hexachords is an inversion of the pitch classes of its other hexachord, ordering considerations aside. Although I do not wish to devote considerable space to the question of inversional combinatoriality or its generalizations, since I have done so previously — albeit informally — in SA, I feel obliged to review certain aspects, for the purpose of introducing necessary concepts, and because of the definitive and consequential role this property plays in the excerpt under discussion.

The hexachordal inversional property can be expressed:

$H_o + T_t I H_o = A$, for some t (1.1) where H signifies "hexachord,"

and the subscript to H denotes the order number associated with the first element of this hexachord (thus, for simplicity, an ordering of the H is assumed, but the property is independent of the particular ordering); I signifies the inversion operator (permutation), and T the transposition operator, with subscript t denoting the transposition number, which — for this type of combinatoriality — can assume any odd integral value (See TT p. 254, and below); where the T operator is omitted, it is understood that t = o. The + sign is used in the sense of set union, and · in the sense of set intersection. The members of the "sets" (hexachord, in this case) are pitch classes; A signifies "aggregate," which — for the moment — may be taken to mean any collection of 12 different pitch classes. It must be recalled that the I and T operators do not commute (or, alternatively, commute only to within complementation mod. 12), and — therefore — the indicated order of operations is signi-

ficant, and is to be read from right to left; the R and I, R and T, and T operators do commute.

Given a t that satisfies (1.1), then from that stated property, the following follow immediately, any one of which could serve equally well as the definition of this type of combinatoriality: $H_o \cdot T_tIH = \phi$ (the empty set); $H_o + T_tRIH_6 = A$; $H_o \cdot T_tRIH_6 = \phi$; $H_o \cdot T_tIH_6 = H_o + T_tIH_6$, etc., etc. by virtue of the rules of formation and transformation of the system itself. (It is necessary to remember that any twelve-tone set possesses the combinatorial attribute that S_{o--n} (the first n order numbers of a set) + RS (n + 1) -- 11 = A.)

Given a set S which possesses only I combinatoriality, there are four (and only four, it will be seen) forms of the set combinatorially related to this S in the sense of (1.1), including S itself. These forms, represented by the operators or associated permutations which effect them (since S is the identity element it is not stated when combined with another operator) can be presented conveniently in a group table:

S	T_tI	R	T_tRI
T_tI	S	T_tRI	R
R	T_tRI	S	T_tI
T_tR I	R	T_tI	S

The combinatorially so-related forms thus constitute a "four group" isomorphic to the group of the totality of set forms, mod. transposition. (It must be understood that T_t, for instance, is not an element of the above displayed group; if it were, this array would not represent a group. T_tI is a single permutation of the group, merely notated in terms of its constituent permutations.)

It is seen, then, that this combinatorial property partitions the, normally, 48 set forms into 12 disjunct collections of set forms; although considered independently (by allowing t in T_tS to equal 0) each of these collections is a "four group," within the group of all forms of a set, only the collection containing S is a sub-group, since S is the identity. Since I have introduced and shall introduce discussions of group structure only to present succinctly the relations among an assemblage of forms, I shall not pursue this discussion further. (The reader with a knowledge of elementary finite group theory will recognize at once the necessary invocation of cosets and imprimi-

tive systems.) Compositionally, criteria of such combinatorial relatedness will provide only four such "functionally related" forms, and other criteria must be introduced to provide for the presentation of other forms, or other such collections of forms, as we shall observe in Example 1.

It is easy to derive, with the most rudimentary formalism, the necessary and sufficient condition for a set's possession of IH combinatoriality. I shall do so, not for purposes of enumeration, since the twelve so distinguished independent source sets ("source sets" in the sense of not signifying a particular ordering within the hexachords, or of the hexachords) are easily constructible, but in order to expose the structure of this class of sets, and to be able to proceed to other, thus seen to be analogous, combinatorial types.

Let "a" be the pitch class number (henceforth abbreviated p.c.n.) of any element of an H, then — by definition of T, I, and this combinatorial property — there must be a p.c.n. "b" in the complementary hexachord of H such that $12 - a + t = b \pmod{12}$ where + denotes, of course, ordinary addition; so that, therefore:

$$a + b = t \pmod{12} \qquad (2.1)$$

(Incidentally, this demonstrates also the fact — derivable in many different ways — that t cannot be even (see above), since there would then be an "a" (and an "a" + 6) such that a = b, contradicting the initial assumption that a + b are in disjunct hexachords). For later purposes, any two collections of p. cs. (not only hexachords) satisfying (2.1) will be termed "inversionally similar." The t in (2.1), therefore, is the transposition number under which I combinatoriality is effected; however, its value is obviously determined by the p.c.n. assigned to a specific "a" (or "b") in any S. If this is not thoroughly understood, designatory ambiguity will result. For example, in the Schoenberg Fourth Quartet, S shall be taken as that set a compositional representation of which is stated at the very beginning of Example 1. Then, if as is customary, the first p.c. of this set is assigned p.c.n. = 0, then the value of t is 5; but, if the whole quartet is under discussion, and — accordingly — the first p.c. of the set presented in the first violin at the work's opening is assigned p.c.n. = 0, then the value of t for the now, in the third movement, T_{10} S is 1. In other words, one is accustomed to think of a transposition number as defined by the interval determined by $(S_{0,a})$ and $T_tI_{(0,\,a+t)}$, but this t is derivable only from these two p. cs. and $S_{I,\,a+6}$

and $T_t I_i$, a + 6 + t (see TT, p. 254), whereas t in (2.1) is the sum of the p. c. nos. $S_{i,a}$ and $T_t I_{i,b}$ where "i" assumes any order number value. Only in this latter sense can one speak of "the" transposed inversion of a S or H which is combinatorially related to the S or H for the general case, as opposed to the transposition of $T_o I$ or the transposition of two elements of S. Therefore, it is suggested that a given H be ordered in "normal form," wherein the interval determined by the first p. c. - last p. c. is greater than any interval determined by successive p. cs in H. (The further specification for "normal form" when there is no such unique interval need not concern us here.)

For the Fourth Quartet, the normal form of H_o of the above designated S is, in ordered p. c. nos. with the first = 0: 0, 1, 4, 5, 6, 8; the combinatorially related IH is: 3, 2, 11, 10, 9, 7; t, in both senses, is 3. The compositional orderings of the two H's are: 0, 11, 7, 8, 3, 1 and 5, 6, 10, 9, 2, 4; here t, in both senses = 5. It must be observed that the symmetry relation between operations of the system makes it impossible to differentiate systematically between t and 12 - t in I related sets.

Much, far too much, importance has been attached to Schoenberg's choice of t = 5 (in the usual sense) for many of his orderings (the Wind Quintet, the Variations for Orchestra Op. 31, and Moses und Aron are significant exceptions). To be sure, since it has been shown that the t value is dependent upon ordering, it may be assumed that the use of this particular t determined the choice of the first p. c. But the other two inversionally related sets of the combinatorial group are, in no way, less important, and for their initial p. c. nos. to define the interval 5 (or 7) would require merely that, if $S_{o,o}$ be the first member of S, then the last element would be $S_{11,1}$ or $S_{11,6}$ or $S_{11,7}$; but Schoenberg does not make this further choice often enough to be considered significant (Op. 33a is an instance). In the Fourth Quartet, the t so determined is 1 (or 11); in Op. 31, where the t determined by what would be designated usually as S and its combinatorially related IS is 9 (or 3), that determined by the other two sets is 5 (or 7), but in Moses und Aron, 5 (or 7) is not determined by either pair of I related sets.

A slight extension of (2.1) results from assuming that for each "a," there are two values of b (and, thus, of t) such that:

$$\begin{aligned} a + b_1 &= t_1 \\ a + b_2 &= t_2 \end{aligned} \qquad (2.2)$$

which requires that b_1 and b_2 define the interval 6, from which it further follows that

$$H_0 + T_t H_0 = H_0 \qquad (1.2)$$

for t = 6. Thus, in addition to the trivial case: $H_0 + RH_0 = A$, it follows that $H_0 + T_6\, RH_0 = A$, and thus the property shall be termed RH combinatorially. There is one, and only one, IH combinatorial source set of the second order (that is, satisfying (2.2) satisfying additionally only (1.2). In one of its two normal forms (identical to within transposition by t = 6) one of its hexachords is: 0, 1, 3, 6, 7, 9. Observe that (1.2) manifests itself in the property that the p.c.nos. of the first trichord are congruent mod. 6 to those of the second trichord. The only other source set satisfying (2.2) is all combinatorial of the second order, and — similarly — the one source set that satisfies (2.1) for three values of b and t, and the one that satisfies it for six values are the third order and fourth order all-combinatorial sets, respectively (See SA, p. 57-8).

(2.1) also suggests a "dual," in which "a" and "b" designate p.c.nos. in the same hexachord of S ("a" and "b," therefore, may be the same number). a + b = t (mod. 12), in this sense, will be numbered (3.1). It follows that b = 12 - a + t, and:

$$H_0 + (\text{or}\cdot)\, T_t I H_0 = H_0 \qquad (3.2)$$

or, equivalently, in a statement analogous to that of (1.1):

$$H_0 + T_t R I H_0 = A \qquad (1.3)$$

so that such hexachords are termed RI combinatorial, and only collections of p.c.nos. satisfying (3.1) will be called "inversionally symmetrical," since such a collection can be mapped into itself under application of I and the appropriate t. Although (1.1) and (1.3), and — above all — (2.1) and (3.1) indicate significant similarities between the structure of IH combinatorial and RIH combinatorial sets, the seven source sets of the latter type differ from those of the former in an immediately manifest respect. (2.1) defines a relation between complementary H's such that one can be considered as derived from the other by the application of a twelve-tone operation: I, but (3.1) defines a property of a single hexachord, so that the complementary H's of an S which possess only this H combinatorial property cannot be so derived from one another. Further, it can be shown that S cannot satisfy (3.1) multiply, so that for each "a" there are two or more

"b's" (and t's) without also satisfying (1.1) and (1.2), and cannot satisfy (1.2) without also satisfying (1.1). The group associated with set forms related in the sense of (3.3) is, again, the "four group."

The remaining possible type of H combinatoriality is termed "prime" combinatoriality, and can be expressed:

$$H_0 + T_t H_0 = A \qquad (1.4)$$

an equivalent form: $H_6 + T_t H_0 = H$ reveals immediately that the disjunct H's of such an S are transpositions of one another. In the notation of (2.1):

$$a + t = b; \quad t = b - a \qquad (4.1)$$

Since b - a is, by definition, the interval determined by the p.cs. "b" and "a," t here designates the transposition relation between the two H's, and — therefore — the interval which must be excluded internally from each H; since a - b = 12 - t, the complementary transposition number of t, if (4.1) is satisfied for only one t, then t must equal 6, the only interval which is its own complement. There is only one source set satisfying (4.1) and no other H combinatorial condition; any S which satisfies (4.1) for more than one b also satisfies (1.1), (2.1), and (3.1); any S which satisfies (4.1) and (1.1) also satisfies (3.1); any S which satisfies (4.1) and (3.1) also satisfies (1.1); any S which satisfies (4.1) and (2.1) satisfies (1.1) and (3.1) multiply. The "four group" associated with the S satisfying (1.4) is:

S	T_t	R	$T_t R$
$T_t S$	S	T_t	R
R	$T_t R$	S	T_t
$T_t R$	R	T_t	S

The final extension of H combinatoriality is the all-combinatorial set: three source sets of first order satisfying (1.1), (1.3), and (1.4), but (1.2) only trivially, for t = 0, and represented by a group of order 8; three source sets which satisfy (1.1), (1.3), and (1.4), and (1.2) doubly, trebly, and sextuply, respectively; the second order set is represented by a group of order 16, the third order set by one of order 24, and the fourth order set by one of order 48. These six source sets are stated in SA (p. 57).

Another direction of generalization of the concept of combinatoriality is suggested by regarding H combinatoriality as a partitioning of an aggregate into two parts of six elements each; in the usual partitional notation, all the combinatorial relations thus far discussed are represented partitionally thus: (6^2). Similarly, a class of combinatorial sets can be associated with each of the 77 partitions of the number 12, ranging from the case where the aggregate is, in fact, a set, a single set form, represented: (12), to that which involves the maximum number of set forms: (1^{12}). The "justification" for this extension need be no more than that an aggregate is thereby assured, in the light of the actual and possible use of the aggregate as a unit of compositional progression containing segments of set forms functionally related through the requirements of aggregate structure. There are singular properties attending the set classes associated with each partition and the classes of these classes. I cannot deal with this enormously extensive subject here; I do wish to point out, however, that even so apparently trivial an unequal partition as (11 1), where the two parts represent, say, RI related sets, is nontrivial when incorporated into the structure of a set which possesses (1.3) combinatoriality for the same t. The condition that S_{1-11} (the final eleven p.cs. of S) + T_tIS_0 = A for the same value of t for which $H_6 + T_tIH_0 = A$ is fulfilled is simply not possible in a first order or third order all-combinatorial set.

The extension from H combinatoriality (6^2) to the remaining equal partitions: (2^6), (3^4), (4^4), (12), (1^{12}), and to the remaining two part partitions: (1 11), (2 10), (3 9), (4 8), (5 7) incorporate immediate generalizations of the fundamental intervallic property of complementary hexachords, the property that the total intervallic content of two hexachords (that is, the 15 intervals of an H, specified most conveniently in the form of the six possible intervals — since complementary intervals are equivalent — with their associated multiplicities) is the same, if and only if the H's are complementary. This property, which is true of any pair of hexachords insures that every H will define an intervallic collection uniquely associated with itself and its complement. Therefore, the 36 intervals not present in either hexachord are formed by the 6 x 6 pairings of the members of the two, complementary hexachords. This characteristic of singular harmonic definition suggests one important reason for Schoenberg's compositional concern with hexachords as combinational units. But this property is but a special case of the more general property associated with any partition of a set into two parts: if S

is partitioned (m n) — m is assumed, by the usual notational convention, to be larger than n — then, it can be shown that, if the multiplicity of any interval i is k in the n-part segment, then it is (m - n) + k in the m-part segment†. The hexachordal property is merely the special case where m=n, and — therefore — m-n = 0††.

An investigation of hexachordal (4^3), trichordal (3^4), dyadic (2^6), or unitary (1^{12}) combinatoriality even as summary as the preceding of H combinatoriality would exceed the appropriate limits of the present article. Rather, I shall present merely an instance of a set embodying such extensions. It is that of my Composition for Twelve Instruments (1948); although the set possesses properties of a complex combinatorial nature, making it susceptible to use in forming aggregates with more than two unequal parts — ($8\ 2\ 1^2$), for instance —, I shall indicate merely its equal-part partitional characteristics for one group of operators. The twelve forms are stated linearly, timbrally in the work; the designation of S is arbitrary.

S:	0,	1,	4,	9,	5,	8,	3,	10,	2,	11,	6,	7.
T_4:	4,	5,	8,	1,	9,	0,	7,	2,	6,	3,	10,	11.
T_8:	8,	9,	0,	5,	1,	4,	11,	6,	10,	7,	2,	3.
T_1I:	1,	0,	9,	4,	8,	5,	10,	3,	11,	2,	7,	6.
T_5I:	5,	4,	1,	8,	0,	9,	2,	7,	3,	6,	11,	10.
T_9I:	9,	8,	5,	0,	4,	1,	6,	11,	7,	10,	3,	2.
R:	7,	6,	11,	2,	10,	3,	8,	5,	9,	4,	1,	0.
T_4R:	11,	10,	3,	6,	2,	7,	0,	9,	1,	8,	5,	4.
T_8R:	3,	2,	7,	10,	6,	11,	4,	1,	5,	0,	9,	8.
T_1RI:	6,	7,	2,	11,	3,	10,	5,	8,	4,	9,	0,	1.
T_5RI:	10,	11,	6,	3,	7,	2,	9,	0,	8,	1,	4,	5.
T_9RI:	2,	3,	10,	7,	11,	6,	1,	4,	0,	5,	8,	9.

These twelve forms (a sub-group of half the order of the total group associated with combinatorially related sets of the third order of H combinatoriality), display (12), (6^2), (3^4), (2^6), and (1^{12}) combinatoriality. For example: H_oS or T_4H_o or T_8H_o or T_1IH_o or T_5IH_o or T_9IH_o + any one of the six remaining H_o's in the table = A; similarly, with trichords: S_o--3 +

† A complete proof of this property, by Michael Kassler, will be published in a subsequent issue of this journal.

†† A discussion of this property for both two-part partitions and partitions with an equal number of parts can be found in the papers by David Lewin in this journal: Vol. III, No. 2 (p. 298-391), and Vol. IV, No. 1 (p.98-101).

$T_9IS_{o}--3$ + $R_{o}--3$ or $T_4R_{o}--3$ or $T_8R_{o}--3$ + $T_9RI_{o}--3$ or $T_5RI_{o}--3$ = A, etc., etc. So, too, with dyads, and with single pitch classes. This latter case is not, as might be assumed hastily, a trivial attribute of any set, for the above table is not a set matrix, containing all set forms, or all the transpositions of any transformation. For all p.cs. of the same order number to produce an A for every order no. for a collection of set forms producing (6^2), (3^4), and (2^6) combinatoriality requires the imposition of stringent conditions upon the structure of S itself.

It will be observed that every possible equal-part partition (and its conjugate) is present except (4^3), the conjugate of (3^4), because every trichord of a third-order H contains at least one interval of 4 (or 8). However, (4^3) combinatoriality is present; not, of course, for every disjunct tetrachord, but among tetrachords containing the four central elements of every set form (this tetrachord is a first-order all combinatorial tetrachord): S_4--7 or T_1I_4--7 or R_4--7 or T_1RI_4--7 + T_4S_4--7 or T_5I_4--7 or T_4R_4--7 or T_5RI_4--7 + T_8S_4--7 or T_9I_4--7 or T_8R_4--7 or T_9RI_4--7 = A.

The large number of aggregates which can be formed as the result of set structure such as this, and the still very much larger number of possible compositional orderings of the p.cs. within each A indicate the extent of available and necessary choice, for all that the systematic ordering within the set segments — determined by the set structure — is "pre-defined" and preserved. The magnitude of the number of compositional statements of aggregates associated merely with a given H combinatorial pair can be inferred from the fact that there are 32 compositions of a single H. Therefore, the importance of this facet of twelve-tone composition, the spatial and temporal disposition of an aggregate and the relation of the structures of successively presented aggregates, can be appreciated as, at least, that of "middleground" harmonic structure, situated hierarchically between the "foreground" structure of simultaneities and their relations, and the larger areas including and subsuming aggregates as their constituents.

Still further — and, in a sense, different — extensions of partitioning are suggested, and have been employed, by extending the notion of an aggregate to include the registral specification of p.c. members so that all partitions less than and equal to those of the number 48 are available; by this approach, instrumental "doubling" and registral rhythm — for example — fall within the domain of combinatoriality, in this extended inter-

pretation.

Again, the 2^{11} compositions of the number 12 all must be examined when the order of parts of a partition of an A is significant, as it is when the parts are — say — assigned linearly to classes of timbres, registers, dynamics, etc. Indeed, any compositional statement of an S or A necessarily is partitioned registrally, instrumentally, dynamically, and temporally.

Although one of the primary compositional applications of combinatoriality has been that of aggregate formation, the progression in twelve-tone units other than a form of S, the extension of the principle to produce "weighted aggregates" (a collection of twelve pitches in which the twelfth pitch does not appear until after, at least, one pitch class has been represented, at least, twice, with each of these representations supplied by segments of different set forms) or — the same concept differently described — "incomplete aggregates") a maximal segment, with no pitch class repetitions of the kind just described, of a weighted aggregate) results immediately from the further properties of the intervallic structure of a subset, which structure completely determines the extent of intersection between such a subset and another of its forms.

The set of the Fourth Quartet possesses combinational characteristics in addition to, and independent of, those of H combinatoriality. Consider the p.c.nos. of the disjunct tetrachords. The first: 0, 11, 7, 8 is inversionally symmetrical, since 0 + 7 = 11 + 8 (see 3.1); the second: 3, 1, 2, 10 and the third: 6, 5, 4, 9 are inversionally similar, since 3 + 4 = 1 + 6 = 2 + 5 = 10 + 9 = 7 (see 2.1). So, under T_7I:$S_{0--3} \rightarrow T_7I_{0--3}$, $S_{4--7} \rightarrow T_7I_{8--11}$, $S_{8--11} \rightarrow T_7I_{4--7}$.

Further, consider the disjunct trichords: the first: 0, 11, 7 and the fourth: 5, 4, 9 are inversionally similar: 0 + 4 = 11 + 5 = 7 + 9 = 4; the second: 8, 3, 1 and the third: 2, 10, 6 are each inversionally symmetrical under t = 4. So, under T_4I: $S_{0--2} \rightarrow T_4I_{9--11}$, $S_{9--11} \rightarrow T_4I_{0--2}$, $S_{3--5} \rightarrow T_4I_{3--5}$, $S_{6--8} \rightarrow T_4I_{6--8}$. Therefore, one sixth of the 48 set forms preserve H, or tetrachordal, or trichordal content.

So little attention has been directed toward the combinational structure of Schoenberg's sets beyond H structure that the examination of another instance seems appropriate. The set is that of the String Trio (it is not here germane to argue whether or not this is the set of the Trio, or whether or not there is such a set. This set and its other forms occur frequently

enough, explicitly, to justify its examination): 0, 8, 1, 7, 2, 11, 9, 6, 4, 5, 3, 10. The t under which (1.1) holds is 5, but it is the tetrachordal structure which is of particular interest. The tetrachord 8, 1, 7, 2 is an ordering of the second-order, all-combinatorial tetrachord, and inversionally symmetrical for two values of t: t = 3, and t = 9. But as we have seen, such a collection must satisfy also (1.2), so that under t = 6 this tetrachord maps into itself. Consider now the forms of S which hold the pitch content of this tetrachord invariant:

S:	0	(8	1	7	2)	11	9	[6	4	5	3]	10
T_6S:	[6]	(2	7	1	8)	[5]	[3]	0	10	11	9	[4]
T_3IS:	[3]	(7	2	8	1)	[4]	[5]	9	11	10	0	[6]
T_9IS:	9	(1	8	2	7)	10	0	[3	5	4	6]	11

In terms of the primary consideration of H structure the tetrachordal structure of this S is clear and striking. The initial and final p.cs. of each H of S (here underlined) are an ordering of a first-order, all-combinatorial tetrachord, and the p.c. remainder of the second H of S (bracketed) is another ordering of the same source tetrachord. Therefore, these four set operations map the latter tetrachord into itself in those forms in which the former tetrachord maps into itself, and into the former tetrachord in those forms in which the former maps into the latter. Also, the tetrachord S_{1--4} is presented ("vertically") by the four p.cs. with order nos. 1, or 2, or 3, or 4. Similarly, the tetrachord consisting of p.cs. with order nos. 5, or 8, or 9, or 11 is a transposition of the same tetrachord as S_{1--4}. The remaining four "vertical" tetrachords are identical within themselves, and are representations of the third-order, all-combinatorial tetrachord. These four set forms are representable as a "four-group."

Returning now to Example 1 and the compositional manifestations of the work's set structure, the opening — completely linear — statement of the S delineates the importance of its hexachordal structure by articulating, through a rest, this set division. (An identical use of a rest can be found in the first linearly explicit statement of the set of Moses und Aron, in Aron's vocal line, on page 32 of the orchestral score (B. Schott's Söhne, Mainz, 1958). The end of the second H, and of the S, is articulated by a change of instrumental texture from a four instrument unison to a single instrument statement, by a change of register from that available to all four instruments to that uniquely available to the cello, and by an

example 1

SCHOENBERG: FOURTH STRING QUARTET, OP. 37

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extreme dynamic change. The combinatorially related form that follows (T_5RI) often is selected by Schoenberg to succeed S (for example, in the statement of the theme in the Variations for Orchestra, the opening of the Concerto for Piano and Orchestra, and in the continuation of the passage from Moses und Aron cited above) since $SH_6 + T_5RIH_o = A$. (This temporally successive compositional representation of set segments forming an A is termed a "secondary set," since — compositionally — it fulfills the set condition of total ordering; the term "aggregate" will be reserved for those compositional cases where the segments are not linearly ordered in relation to each other. Context will discriminate the uses of the term "aggregate" in the compositional and systematic senses.) Also, the intervallic identity between any two R I related forms provides immediate intervallic repetition. In Example 1, the H structure of the T_5RIS, and — therefore — the extent of the secondary set, is articulated by the instrumental partitioning of H_o into $(2^2 1^2)$ while H_6 is partitioned into only one part, stated unaccompanied by the first violin. The entrance of the next combinatorially related form, R, is in the other three instruments which present H_o, but then H_6, again, is assigned to the first violin alone. Here is a manifest, if simple, instance of what can be termed accurately "structural orchestration," a vast and important aspect of twelve-tone composition. After the statements of S and T_5RI, the progression through secondary sets necessarily ends (only a repetition of S could continue it); the H_o of the R that now follows (as would also have been true of T_5I) taken together with T_5RIH_6 cannot create such a set, rather, $T_5RIH_6 + RH_o = H$; but, therefore, $T_5RIH_6 + RH_6 = A$, and — with H's ordered — a secondary set; it is this hexachordal succession which is presented by the first violin.

After the statements of S, T_5RI, and R, the remaining related form T_5I is not stated; it is reserved for a more definitive role, to be discussed later. An I form is stated next, however, as one component of the first simultaneous statement of combinatorially related forms, temporally juxtaposed to provide a succession of aggregates. This measure, also, will be discussed in detail below.

The opening statement of S is characterized most strikingly by the repetition of the dyad (G^b, F), isolated by rests, as the sole deviation from the direct linear statement of the set members; similarly, the dyad (C, B) is repeated in the complementary H of T_5RI, and isolated instrumentally. The choice of these dyads for such singular treatment creates a

direct association between the two set forms by so identifying ordered adjacencies which are common to the two sets, almost unique adjacencies, since they are the first two members of the unique, ordered trichords: (C, B, G) and (B^b, G^b, F). The use of the total trichord in this function is delayed until a later stage of the movement; see — for instance — m. 636-7. These dyads serve to articulate the beginning and end of the two-set complex, since (G^b, F), repeated in the first set, is the final dyad of the second set, and (C, B), repeated in the second set, is the initial dyad of the first set.

Fixed adjacency structure, since it is a matter of ordering, essentially is independent of H structure. For a succession of p. c. nos. (a, b) in any S to remain fixed under, for some t, T_tI, S must contain the succession (c, d), where a + c = b + d, for 12 - a + t = C; 12 - b + t = d; t = a + c (and b + d). Under this t, a→c, b→d, c→a, and d→b. If T_tRI is substituted for T_tI in this expression, the order of c, d must be reversed. Thus, here, (c, b) maps into (G^b, F) under T_5RI because the sum of the p. c. nos. of c and F = 5, and similarly the sum of b and G^b = 5. And t = 5 is, of course, the H combinatorial value of t.

The repeated (A, B^b) and (E, D) in 621-2 are statements of dyadic adjacencies of the preceding T_5RIH_6, but they are not adjacencies in R, but compositionally secured through the instrumental partitioning of RH_o, which partitioning is also an obvious reflection of the registral disposition of T_5RIH_6.

The general treatment of the question of adjacency invariance in connection with H structure is handled most efficiently with the notation and methods of permutations. Thus, the H_6 of a specific S can be regarded as a permutation of the order nos. of a T_tIH_o where t satisfies (1.1). In these terms, for the case here $\begin{pmatrix} 0 & 1 & 2 & 3 & 4 & 5 \\ 3 & 2 & 1 & 5 & 0 & 3 \end{pmatrix}$, with the upper row representing the order nos. of T_5IH_o and the lower their ordering in H_6 (of S), the adjacency structure preserving the (here) reversed trichord is, at once, obvious.

In Example 1 the first element of T_5RI creates, with the final two elements of S, a trichordal succession (E, A, A^b) which is a form of a trichord stated and repeated within S: (G, A^b, E^b) and (F, E, A). An immediate "motivic" repetition is created by the overlap of this (F, E, A) with (A, A^b, D^b). This immediate means of joining the successive set statements is very much a result of the order structure of S; one need but reverse

the final two elements of S to secure ($S_{10,9}$, $S_{11,4}$, $T_5RI_{0,1}$), a trichord form not present in S.

Before devoting virtually the remainder of this article to a consideration of the transpositional choice in m. 623, I shall touch summarily on a few other aspects of this passage.

The registral disposition of an S or A statement is independent, systematically, of set structure; indeed, questions of specific instrumental limitations aside, any S or A can be ordered spatially in 12! ways. This alone emphasizes how consequential musically is the compositional choice of registral arrangement, both from a standpoint of internal structure and from that of progression, with its attendant linear-registral considerations. Although references have been made to Webern's procedure of maintaining a contextually established disposition over an extended part of a work, this facet of Schoenberg's music has been neglected. I restrict myself here to one aspect of the registral structure of m. 614-23. S is registrally disposed in the minimum possible space, the extrema defining an (absolute, non-modular) interval of 11; the mid-pitches of this particular disposition are C and D^b. That they are literally stated is trivial here, because of the minimal registral span of S, but — significantly — they are the pitches of greatest duration in the statement of S. This association of some type of musical emphasis with the explicitly stated mid-pitch (or pitches) of a registral disposition is conclusively characteristic of this passage. The following statement of T_5RI is disposed over an interval of 45, the mid-pitches are the explicitly stated (this is not trivial here), uniquely emphasized C and B in the second violin, held fixed registrally from S. Similarly, the statement of R, defining an interval of 32, has as its mid-pitch the explicitly stated, repeated A of the second violin. Any lingering suspicion of fortuitousness should be dispelled by m. 623. Consider, first, the disposition of the total set pair, the T_9S in the cello and the combinatorially related T_2I partitioned (9 3) by the viola and second violin. The registral interval is 21, the mid-pitches are C♯ and D, the only two pitches held registrally fixed between the two aggregates of the measure. To achieve this Schoenberg made one, and only one, change in the registral disposition of S when stated here as T_9S: the E^b in the cello of 623 is an octave lower than the element of the same order number in S, thus making this the lower extreme of the measure. If the original disposition had been maintained, then D alone would have been the mid-pitch, and — if it were to be emphasized uniquely by registral repetition — then the C♯ of the cello would have to

be changed registrally, thus becoming the lowest (or highest) note of the measure, altering the disposition. It should be noticed, also, that the mid-pitches of the individual aggregates are the same D, C#; this is trivial in the case of the second aggregate, which contains both extrema, but not so in the case of the first aggregate, whose interval number is 19. The change of the registral disposition of S as T_9S now makes the first two notes of the cello, the A and G#, the mid-pitches of this set; the importance of this dyad in other respects is discussed below.

Correspondingly, I will restrict myself to but one observation on the "rhythm" of this excerpt, sufficient however to serve as a counterexample to the assertion that Schoenberg's rhythm is "unrelated" to the twelve-tone structure of his pitches. Consider the temporal duration of the successive set statements: S = 4 3/4 measures, Secondary Set 4 (approx.), T_5RI = 2 3/4, R = 1 3/4 (approx.), and $T_9S + T_2I$ = 1. I am not concerned with the absolute values of the durations, but with the use of the sets as units of durational definition, effecting a successive durational reduction to and including the first point where different set forms are combined simultaneously. Obviously, set (or aggregate) rhythm in this sense is employed as an analogue of harmonic rhythm in the triadic sense.

Associative harmony in the small is employed in this passage much as in, for example, such a non-twelve-tone work as Op. 23/3. These identities are virtually self-evident: that of the aggregate-formed simultaneity on the second beat of m. 623, and the set-formed simultaneity on the second beat of m. 619; the exact inversional identity of the trichord on the first beat of m. 623 with that of the fourth beat of m. 621 (and the first beat of m. 622); the preparation of the "obligatory" combinatorial interval 5 (stated explicitly by the initial notes of the cello and viola in m. 623) by the explicitly attacked, simultaneous dyads (G, C) on the second beat of m. 619, (B, E) on the first beat of m. 620, and (E, A) in m. 621; the vertical intervals (5, 8) associated with the A and B^b of the second violin in m. 621-2 repeated in succession with the next two pitches of the second violin (B, C), created by the second violin and viola, again.

Now, at last, I shall examine the choice of t = 9 for the statement of S in m. 623. Most immediately, there is the identification of the first note of T_9S with the last of S. This identification is combined cyclically through a circuit of pitch classes by successive transpositions of S, defining — as initial and

terminal p.cs.: C--A (in S), A--F# (in T_9S), F#(G^b)--E^b (in T_6S, m. 626-7), and E^b--C (in T_3S, m. 628); the next statement of a T_tS is S itself in the following section of the movement (m. 633). This cyclical connection of similar set forms ("similar" signifying identity to within transposition) is available regardless of the structure of S; the interval of transposition is determined by $S_{0,a}$ and $S_{11,b}$, and the number of sets required to construct the circuit is $\frac{12}{b-a}$ or, equivalently, $\frac{12}{a-b}$. However, if there are other bases for choosing the transposition number, then the relation of the first and last p.cs. of S can be so determined. In the example here, the choice of t = 9 creates initial-terminal succession C-A-F#-E^b, a "diminished seventh" outline which reflects still another characteristic of the structure of S. If the p.cs. of S are written mod. 3, the following results:

0, 2, 1, 2, 0, 1, 2, 1, 0, 2, 1, 0,

Each disjunct trichord contains one, and—thus—only one, element from each residue class, mod. 3; informally, it can be said that each trichord contains one element from each of the three "diminished seventh chords" which are available among the twelve pitch classes. These trichords, which play an explicit compositional role in the work (the very opening of the first movement, for example), then define a progression through the "diminished" seventh, as do the transpositions of S in the third movement. A similar succession could be achieved by setting t = 3, but this could not be also the basis of a terminal-initial succession, since p.c. numbers 0 and 3 are both in the first hexachord of S.

The immediate identificatory function of the initial note A in m. 623 is extended to the dyad of which it is the first member, for the succession (A, G#), phrased together, it should be noticed, continues the pitch identity with m. 618, where (A, A^b) is the dyadic join of S and T_5RI. For this to be available in a S, $S_{0,0}$ and $S_{1,a}$ must define an interval "a" equal to that defined by $S_{11,b}$ and T_tRI_0, 12 - b + t; if the t determines a (1.1) combinatorial relation, then it is itself a function of $S_{0,0}$. The dyad (A, G#) is stated simultaneously or successively (in this order, or reversed) once or more in each succeeding measure of this section of the movement, culminating with the (A, G#), each pitch under a fermata, the highest pitches of the section (the same registral placement of these pitches occurs also four measures earlier), at the end of the section (m. 629). The A, G# as mid-pitches have been mentioned above. Identifica-

tion of the cello A of m. 623 with the terminal A of S is clarified further by the simultaneous statement of C ($R_{11,0}$) in the first violin, thus providing a simultaneous presentation of the first and last notes of S, the former even in its original register.

But the choice of t = 9 in m. 623 effects more complete and fundamental associations, if sonically less immediate ones, instancing more general principles than those just observed. Since the sum of the pitch members of all pairs of elements with the same order numbers in I related sets is the same, the distribution of the elements of an S into such pairs for any $T_{t_1}S$, $T_{t_2}I$ juxtaposition is determined completely by the pitch numbers of S, since $S_{m,a}$ and $S_{n,b} \rightarrow T_{t_1}S_{k,a}$, $T_{t_2}I_{k,b}$ and, of course, $T_{t_1}S_{l,b}$, $T_{t_2}I_{l,a}$ if, and only if, $a + b = t_1 + t_2$. More specifically, two successive pitch numbers (a, b) of S are associated with the same order nos. of the I related sets if $a + b = t_1 + t_2$. In the Quartet S, the pitch number sum of the pitch successions (C, B), and (F, G^b) is, in both cases, 11. (The importance of these dyads in previously discussed regards must not be forgotten.) The "identification" of these "horizontals" as "verticals" in I related sets requires that the $t_1 + t_2$ associated with these sets sum to 11. If, as here, $t_2 - t_1 = 5$ to effect H combinatoriality between the I related sets, then t_1 must satisfy the expression: $t_1 + t_1 + 5 = 11$, and therefore t = 9 or 3; the first value is that chosen in 623, the second that occurring in the last set of the circuit (see m. 628 in the score).

The procedure, as a determinant of transpositional choice, plays a fundamental role in other works of Schoenberg, for instance, in the Phantasy for Violin. The initial S (H combinatorially related) T_5I are:

S: 0, 11, 3, 1, 7, 9, 6, 2, 10, 5, 8, 4
T_5I: 5, 6, 2, 4, 10, 8, 11, 3, 7, 0, 9, 1

At measure 21, the first transposition of S occurs, with its associated I; t = 9, and the t associated with I then must be 2, and their sum = 11, which is the value of the sum of the first two pitch numbers of S and T_51. Thus, these successive elements become simultaneities:

S_9: 9, 8, 0, 10, 4, 6, 3, 11, 7, 2, 5, 1
T_2I: 2, 3, 11, 1, 7, 5, 8, 0, 4, 9, 6, 10

The initial successive dyads of S_9 and T_2I, since their sum is

5, were simultaneities in the statements of S and T_5I.

The next (m. 25) transposition of the pair of sets proceeds similarly, by another interval of 9, so that in T_tS, t = 6, and in T_tI, t = 11; this constitutes a return to the simultaneous dyads of the initial statement, since 6 + 11 = 5:

T_6S: 6, 5, 9, 7, 1, 3, 0, 8, 4, 11, 2, 10.
$T_{11}I$: 11, 0, 8, 10, 4, 2, 5, 9, 1, 6, 3, 7.

In the Fourth Quartet, the total intervallic structure of H_0 (and, therefore, of H_6 as well) possesses a characteristic highly relevant to the choice, t = 9. One, and only one, interval occurs only once: 6. The G and D^b of H_0, and the B^b and E of H_6 (which, incidentally, combine to form a "diminished seventh chord," again), therefore, define H_6 as a transposition of H_0 by the interval of 9 or 3 (since the interval 6 is its own complement, no choice between these complementary intervals can or need be made). This is analagous to characterizing the G major scale as a transposition by a perfect fifth of the C major scale, solely in terms of the intervallic relation between the unique intervals (coincidentally, also 6) of the two scale pitch collections. In these terms, T_9S is to S, as SH_6 is to SH_0. The significance of this aspect of the structure of S is revealed more directly when it is seen that, therefore, under T_9: $(G, D^b) \rightarrow (E, B^b)$ and $(B^b, E) \rightarrow (G, C\#)$; under T_6: $(G, D^b) \rightarrow (C\#, G)$ and $(B^b, E) \rightarrow (E, B^b)$; and, under T_3: $(G, D^b) \rightarrow (B^b, E)$ and $(B^b, E) \rightarrow (D^b, G)$. Thus, the circuit of transposed S's may be described as defining an imprimitive system with regard to the pitch content of the tritones contained in disjunct hexachords. These sets form a group of order four (but not a "four group"), and there are three such isomorphic groups each associated with a so-related pair of tritones, and generated by the four members of the residue classes, mod. 3. Thus, in m. 614-29, every disjunct H contains either the tritone of H_0 or that of H_6, in the same or reversed order, regardless of the set form involved; this, of course, follows from the above by the very nature of IH combinatoriality. Such an instance is but a slight indication of the profound importance of the intervallic content of an H, and — therefore — of the intervallic relations between complementary two part partitions of an S (or A).

Now, also, the significance of t = 3 as determined by the inversional relation between H_0 and H_6 when H_0 is stated in normal form is obvious.

The instrumental partitioning (9 3) of T_2I in m. 623 not only places in the second violin a permutation of the fifth, sixth, and seventh pitches of T_9S, relating these trichords by RI, but the remaining pitches of T_2I, in the viola, relate the first four note, sixteenth note succession to the second according to the following intervallic patterns: 1, 4, 12-1; 4, 1, 12-4; and the first four elements of T_9S, supplying — necessarily — the interval succession: 12-1, 12-4, 1, are now identical — in totality — with the last four of T_2I, while the remaining two attacks of the viola reverse the final dyad of T_9S.

Example 2

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Example 2 demonstrates Schoenberg's use of combinatorially determined criteria as determinants of external structure: "form," in the sense of the deployment of areas of thematic, textural, rhythmic, and comparably manifest similarities. Example 2 is a return, the only return, to the unison statement, the tempo, the rhythmic structure (with one tiny exception), and the metric of the movement's opening. The set form is T_5I, the one form H combinatorially related to S omitted, as observed above from the opening succession of set statements. This "functional transposition" of S assures that (F, G^b) now occupies the positions held by (C, B) in S, and (B, C) those of (G^b, F). Now, the repeated notes of the set statement in this "isorhythmic" repetition are (B, C), and those of the following RI related form (R) are (G^b, F). The terminal and initial notes of these so related forms are the familiar (A^b, A), etc., etc. All of these features are results of the principles

discussed above. This successive statement of what, in simultaneous statement, would produce a note-against-note combinatorial presentation of two, pitch dyad identical, successive aggregates is time-congruent "form" of the most definitive sort.

If many of the topics investigated in this paper have been treated only cursorily, one entire domain of the relation of set structure to compositional structure has been omitted entirely: the combinatorial areas associated with the subsets of S, through derivation (see SA, p. 59-60). This omission has been dictated by the asserted concern with the Schoenberg example (Schoenberg never employed derivation explicitly and independently, for all that — for example — the secondary set formed by SH_6 and T_5RIH_0 can be regarded as derived from SH_6), and the enormous scope of the subject, which conjoins the techniques of Schoenberg and Webern in a generalization whose compositional implications are comprehensive, vast, and challenging.

THEORY FORUM

WILFORD W. BERARD

The harmonic series under the article, Harmony, in the Encyclopedia Britannica's 1959 issue gives the 11th partial of C as F, the 13th as A. This concurs with Helmholtz, Prout, Forsyth, and others. However, most books on harmony or acoustics give F♯ as the 11th partial of C, A as the 13th. Included here are those by Riemann, Schenker, Lenormand, Hanson, and Miller. Hindemith gives F♯ as the 11th partial, A^b as the 13th:

Example 1

We know, of course, that the exact sounds of a harmonic series can be shown only imperfectly by means of musical notation, and that the notes shown above are — or were intended to be — the symbols of the equal tempered sounds closest to the harmonic series of Great C. From this fact, plus the facts given in the first three paragraphs, it is obvious that there is a difference of belief as to whether the 11th partial is closer to an equal tempered F or to an equal tempered F#, and as to whether the 13th partial is closer to an equal tempered A or to an equal tempered A^b. How are we to determine which of these "authorities" are wrong and which are right? The only sure way is to figure the problem out for ourselves. This is a mathematical problem, and, like many such problems, can be solved in more than one way. The way I shall now outline is probably as simple, and therefore as intelligible, as any.

Considering the 11th partial first, and assuming a fundamental of C, what we must do is

A. Determine the frequency of this 11th partial
B. Determine the frequency of a sound lying exactly midway between the equal tempered F that lies just below and the equal tempered F# that lies just above this 11th partial
C. Compare the frequency of this "midway" sound with that of the 11th partial to see which is the higher (and which the lower) of the two.

A. The frequency of the 11th partial of C depends, of course, on the frequency of C. Let us arbitrarily select a philosophical 64 as frequency of our C. Our 11th partial would then have a frequency of 64 x 11 = 704:

Example 2

B. The frequency of a sound lying exactly midway between the equal tempered F that lies just below and the equal tempered F# that lies just above our 11th partial can be found

by multiplying 512 by the 11th power of the 24th root of 2 — $512\left(\sqrt[24]{2}\right)^{11}$. The "why" of this can perhaps be more easily grasped by those who understand the mathematics of dividing an octave into 12 equal parts, as is done in equal temperament.

An octave is divided into 12 equal parts by means of the 12th root of 2. The frequency of the lower note of the octave multiplied successively by $\sqrt[12]{2}$, $\left(\sqrt[12]{2}\right)^2$, $\left(\sqrt[12]{2}\right)^3$, $\left(\sqrt[12]{2}\right)^4$, etc. gives the frequencies of the notes lying one, two, three, four, etc., semitones above the lower note. For example,

If C has a frequency of (say) 64

C# (D^b) has a frequency of $64\sqrt[12]{2}$

D has a frequency of $64\left(\sqrt[12]{2}\right)^2 = \left(64\sqrt[6]{2}\right)$

D# (E^b) has a frequency of $64\left(\sqrt[12]{2}\right)^3 = \left(64\sqrt[4]{2}\right)$

etc., up to

C, which has a frequency of $64\left(\sqrt[12]{2}\right)^{12}$ (=64 x 2 = 128).

Similarly, an octave would be divided into 24 equal parts by means of the 24th root of 2. Thus,

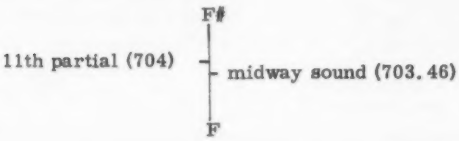
if C has a frequency of 512
a sound lying exactly
midway between C and C# has a frequency of $512\sqrt[24]{2}$
midway between C# (D^b) has a frequency of $512\left(\sqrt[24]{2}\right)^2$
midway between C# and D has a frequency of $512\left(\sqrt[24]{2}\right)^3$
midway between D has a frequency of $512\left(\sqrt[24]{2}\right)^4$

etc., up to
a sound lying exactly
midway between F and F# has a frequency of $512\left(\sqrt[24]{2}\right)^{11}$
etc.

Example 3

If one had to start from scratch to determine the 24th root of 2, the amount of computation involved would be prodigious. Fortunately, however, there is no need to do so. Many books (for example, Redfield's Music A Science and an Art, p. 55) give the 12th root of 2, which is 1.059463. Since a 24th root is the square root of a 12th root, all we need do is extract the square root of 1.059463. Doing so gives us, as 24th root of 2, 1.029302. To raise this number to the 11th power we may again avail ourselves of a shortcut. Redfield gives 1.334840 as the $\left(\sqrt[12]{2}\right)^5$. Since the $\left(\sqrt[12]{2}\right)^5$ is the same as the $\left(\sqrt[24]{2}\right)^{10}$, we need only raise this number one more power; in other words, multiply 1.334840 by 1.029302. Doing so gives us, as the 11th power of the 24th root of 2, 1.373953. Multiplying this number by 512 gives us, as frequency of a sound lying exactly midway between the equal tempered F lying just below and the equal tempered F# lying just above our 11th partial, 703.46.

C. Our 11th partial has a frequency of 704, and our "midway sound" has a frequency of only 703.46. It is clear, then, that the 11th partial of C lies closer to an equal tempered F# than to an equal tempered F.



It follows, of course, that the Encyclopedia Britannica, Helmholtz, and any and all others who give F as the 11th partial of C are in error.

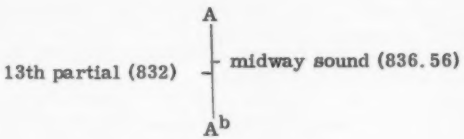
Now let us consider the 13th partial. Since my method of computation is, or should be, clear from the foregoing, I shall try to be brief.

A. Frequency of 13th partial = 64 x 13 = 832

B. Frequency of sound lying exactly midway between A and $A^b = 512\left(\sqrt[24]{2}\right)^{17}$. To simplify $512\left(\sqrt[24]{2}\right)^{17}$ we may again make use of Redfield, who gives 1.587401 as $\left(\sqrt[12]{2}\right)^8$, which is the same as $\left(\sqrt[24]{2}\right)^{16}$ Raising this number one more power

(1.587401 x 1.029302) gives us, as 17th power of the 24th root of 2, 1.633916. Multiplying this by 512 gives us, as frequency of a sound lying exactly midway between A^b and A, 836.56.

C. Comparing, we see that the frequency of the 13th partial, 832, is less than the frequency of the midway sound. Therefore, the 13th partial of C is closer to an equal tempered A^b than to an equal tempered A.



It follows, here again, that among the better-known modern writers on harmony or acoustics, Hindemith alone is right in the notation of the 13th partial.

For well over a hundred years this partial has almost always been given as A. How is it possible for so many to be wrong over so long a period of time? Seemingly, it is simply a case of an error being copied over and over again, from volume to volume, textbook to textbook.

With a view to discovering the possible origin of the errors of notating the 11th partial as F and the 13th partial as A, let us now compare these two partials with the F's, F♯'s, A's, and A^b's of the three most important temperaments that antedated the equal: the Pythagorean, the meantone, and the just. In order to clearly understand the mathematics that doing so will necessarily entail, the following facts must be borne in mind:
We speak of adding one interval to another to form a larger interval. For example, a pure major third plus a pure minor third equals a pure fifth. Or a pure fifth plus a pure fifth equals a pure major ninth. If, however, in place of these ordinal designations (third, fifth, ninth) we use ratios, we must express these ratios as fractions, and multiply. Thus the two preceding examples expressed mathematically would be 4/5 x 5/6 = 2/3 (=2:3) and 2/3 x 2/3 = 4/9 (=4:9)
Similarly, we speak of subtracting one interval from another; as, a pure fifth less a pure major third equals a pure minor third; or a pure major ninth less a pure fifth equals a pure fifth. In this case we divide the ratios expressed as fractions — the larger by the smaller, of course. Thus the two pre-

ceding examples expressed mathematically would be

$2/3 \div 4/5 = 2/3 \times 5/4 = 5/6$ (=5:6)

and $4/9 \div 2/3 = 4/9 \times 3/2 = 2/3$ (=2:3)

Pythagorean temperament concerned itself primarily with pure fifths. Every note was one or more pure fifths above or below every other note. F was pitched one pure fifth below C; or, considered as fourth degree of the C scale, a pure fourth above C. C to F, then, had a ratio of 3:4. With a 512 C, F had a frequency of $512 \times 4/3 = 682\ 2/3$

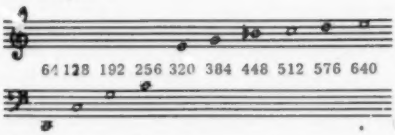
F♯ was pitched six pure fifths above C; or, considered as "raised fourth degree" of the scale of C, six pure fifths above C, less three octaves. C to F♯, then, had a ratio of

$(2/3 \times 2/3 \times 2/3 \times 2/3 \times 2/3 \times 2/3) \div (1/2 \times 1/2 \times 1/2) = 64/729 \div 1/8 = 64/729 \times 8 = 512/729$ (=512:729)

With a 512 C, F♯ had a frequency of $512 \times 729/512 = 729$

To find the frequency of a sound midway between two given frequencies, we must multiply the given frequencies by each other and extract the square root. That this is so may be easily seen from the following:

Example 4



In the preceding example:

1. The sound with a frequency of 128 is midway between the sound having a frequency of 64 and the one having a frequency of 256. ($\sqrt{64 \times 256} = \sqrt{16,384} = 128$).

2. The sound with a frequency of 192 is midway between the sound having a frequency of 64 and the one having a frequency of 576. ($\sqrt{64 \times 576} = \sqrt{36,864} = 192$).

3. The sound with a frequency of 256 is midway between the sound having a frequency of 128 and the one having a frequency

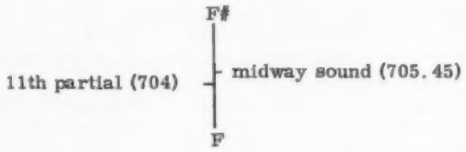
of 512. ($\sqrt{128 \times 512} = \sqrt{65,536} = 256$).

4. The sound with a frequency of 384 is midway between the sound having a frequency of 256 and the one having a frequency of 576. ($\sqrt{256 \times 576} = \sqrt{147,456} = 384$).

Accordingly, to find the frequency of a sound midway between our Pythagorean F (682 2/3) and our Pythagorean F# (729), we must multiply these two numbers by each other and extract the square root:

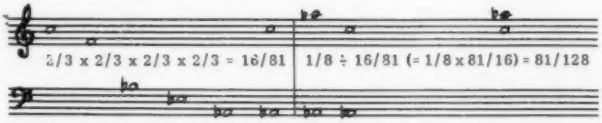
682 2/3 x 729 = 497,664 and $\sqrt{497,664} = 705.45$

Since a sound midway between our Pythagorean F and our Pythagorean F# would have a frequency of 705.45, and our 11th partial has a frequency of only 704, clearly the latter is closer to a Pythagorean F than to a Pythagorean F#:



In Pythagorean temperament A^b was pitched four pure fifths below C; or, considered as sixth degree of the scale of C minor, four pure fifths below C, up three octaves. C to A^b, then, had a ratio of 81:128

Example 5



With a 512 C, A^b had a frequency of 512 x 128/81 = 809 7/81

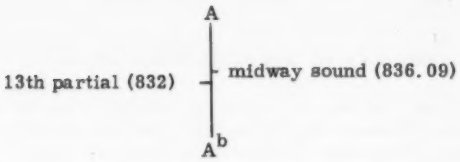
Pythagorean A was pitched three pure fifths above C; or, considered as sixth degree of the scale of C, three pure fifths above C, less an octave. C to A, then had a ratio of

(2/3 x 2/3 x 2/3) ÷ 1/2 = 8/27 ÷ 1/2 = 8/27 x 2 = 16/27 (= 16:27)

With a 512 C, A had a frequency of 512 x 27/16 = 864

As before,
$\sqrt{809\ 7/81 \times 864} = \sqrt{699,050\ 2/3} = 836.09$

Since a sound midway between our Pythagorean A^b and our Pythagorean A would have a frequency of 836.09, and our 13th partial has a frequency of only 832, clearly the 13th partial in Pythagorean as well as in equal temperament is closer to A^b:



In conclusion if, as I have hypothesized, notating the 11th partial of C as F and the 13th partial as A (a combination still seen in a few volumes today), or the 11th as F# and the 13th as A (the combination seen in most volumes today) stems from copying much older volumes in which the harmonic series were notated in terms of two of the temperaments that antedated the equal (one accounting for the F-A combination, the other for the F#-A combination), it is clear that the Pythagorean was not one of these two, because, as we have just proved, the Pythagorean demanded an F-A^b combination.

While meantone temperament is now obsolete, it did prevail "all over the Continent and in England for centuries. . . ." Before the advent of equal temperament, keyboard instruments were usually tuned in meantone temperament, the latter being not completely superseded by the former until about the middle of the 19th century.

If we proceed up four pure fifths from the note C, we arrive at an E which when brought down exactly two octaves forms with C a third — called a Pythagorean major third — having a ratio of

$(2/3 \times 2/3 \times 2/3 \times 2/3) \div (1/2 \times 1/2) =$
$16/81 \div 1/4 = 16/81 \times 4 = 64/81\ (=64:81)$

The Pythagorean major third is slightly larger than the pure major third (4:5). The difference in their sizes is called a

comma. It will be seen that a comma has a ratio of

$64/81 \div 4/5 = 64/81 \times 5/4 = 80/81$ (=80:81)

The underlying principle of meantone temperament was to make each fifth slightly less than pure so that the note arrived at after a succession of four such fifths (called meantone fifths) would form, after being brought down two octaves, a pure major third above the note started from. (Meantone fifths were impure to so slight a degree as to be inoffensive to the ear, that is, they were scarcely distinguishable from pure fifths.) To get rid of the comma in "four moves," each fifth had to be made smaller by exactly one quarter of a comma. Mathematically expressed, a quarter of a comma is $\sqrt[4]{80/81}$. A meantone fifth, then, being a pure fifth less a quarter of a comma, had a ratio of

$2/3 \div \sqrt[4]{80/81} = 2/3 \div \sqrt[4]{80}/\sqrt[4]{81} = 2/3 \times \sqrt[4]{81}/\sqrt[4]{80} =$
$2/3 \times 3/\sqrt[4]{80} = 2/\sqrt[4]{80} = 2/\sqrt[4]{16 \times 5} = 2/2\sqrt[4]{5} =$
$1/\sqrt[4]{5}$ (= 1: $\sqrt[4]{5}$)

When a meantone fifth was subtracted from an octave, the remainder was obviously a meantone fourth, whose ratio was

$1/2 \div 1/\sqrt[4]{5} = 1/2 \times \sqrt[4]{5} = \sqrt[4]{5}/2$ (= $\sqrt[4]{5}$:2)

Since C to F in meantone temperament had a ratio of $\sqrt[4]{5}$:2, with a 512 C, F had a frequency of

$512 \times 2/\sqrt[4]{5} = 1024/\sqrt[4]{5} = 1024/1.49535 = 684.7895$

F# was pitched six meantone fifths above C; or, considered as raised fourth degree of the scale of C, six meantone fifths above C, less three octaves. C to F#, then, had a ratio of

$(1/\sqrt[4]{5})^6 \div 1/8 = (1/\sqrt[4]{5})^6 \times 8 = 1/5\sqrt{5} \times 8$
$8/5\sqrt{5}$ (=8:5$\sqrt{5}$)

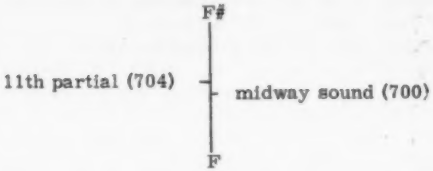
With a 512 C, F# had a frequency of

$512 \times 5\sqrt{5}/8 = 512 \times 11.18034/8 = 715.5418$

As before,

$\sqrt{684.7895 \times 715.5418} = \sqrt{489,995.511} = 700.0$

Since a sound midway between our meantone F and our meantone F# would have a frequency of only 700, and our 11th partial has a frequency of 704, obviously the latter is closer to a meantone F# than to a meantone F:



Although a few keyboard instruments tuned in meantone temperament contained more than 12 notes to the octave, these were very rare. Most contained only the 12 notes, their tuning consisting of a series of 11 meantone fifths starting with E^b and ending with G#. Since this temperament contained no A^b, what we must do, now that we are about to consider the 13th partial in relation to this temperament, is determine whether this partial was closer not to A^b or A, but to G# or A.

The note G# was pitched eight meantone fifths above C; or, considered as raised fifth degree of the scale of C, eight meantone fifths above C, less four octaves. C to G#, then, had a ratio of

$(1/\sqrt[4]{5})^8 \div (1/2)^4 = 1/25 \div 1/16 = 1/25 \times 16 = 16/25$ (= 16:25)

With a 512 C, G# had a frequency of

$512 \times 25/16 = 800$

The note A was pitched three meantone fifths above C; or, considered as sixth degree of the scale of C, three meantone fifths less an octave. C to A, then, had a ratio of

$(1/\sqrt[4]{5})^3 \div 1/2 = (1/\sqrt[4]{5})^3 \times 2 = 2/(\sqrt[4]{5})^3$ (=2:$(\sqrt[4]{5})^3$

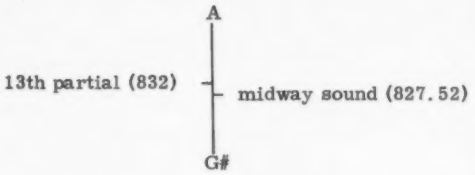
With a 512 C, A had a frequency of

$512 \times (\sqrt[4]{5})^3\ 2 = 512 \times 3.3437/2 = 855.987$

As before,

$\sqrt{800 \times 855.987} = \sqrt{684,789.6} = 827.52$

Since a sound midway between our meantone G# and our meantone A would have a frequency of only 827.52, and our 13th partial has a frequency of 832, the latter is obviously closer to a meantone A than to a meantone G#:



To conclude, during the era when most keyboard instruments were tuned in meantone temperament, it would seem most natural that musicians should notate the harmonic series in terms of this temperament, and doubtless this is exactly what many of them did. The harmonic series so notated would, as we have just proved, show F# for the 11th partial of C, and A for the 13th partial. This notation was copied even as equal temperament gradually superseded meantone temperament, continued to be copied when the supersession was complete, and continues to be copied down to the present day. I present this not as an historical fact, but as a possible explanation of the origin of the now-erroneous F#-A combination seen in most notations of the harmonic series today.

In just temperament, as in Pythagorean, F considered as fourth degree of the scale of C is pitched a pure fourth above this C. It therefore has the same frequency as a Pythagorean F, which, with a 512 C is 682 2/3.

F#, however, is pitched a pure major third above D, which is pitched a pure fifth above G, which is pitched a pure fifth above C. This F#, when brought down an octave, forms with C an interval having the ratio of

$(2/3 \times 2/3 \times 4/5) \div 1/2 = 16/45 \div 1/2 =$
$16/45 \times 2 = 32/45$ (=32:45)

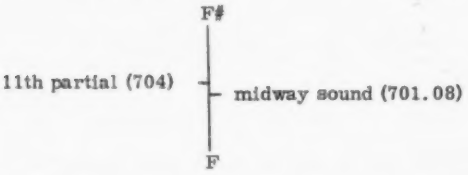
With a 512 C, then, F# has a frequency of

$512 \times 45/32 = 720$

As before,

$\sqrt{682\ 2/3 \times 720} = \sqrt{491,520} = 701.08$

Since a sound midway between our just F and our just F# would have a frequency of only 701.08, and our 11th partial has a frequency of 704, the latter is obviously closer to a just F# than to a just F:



The ratios of the just minor sixth (5:8) and the just major sixth (3:5) are so well known that I shall dispense with the mathematics of their origins.

With a 512 C, A^b would have a frequency of

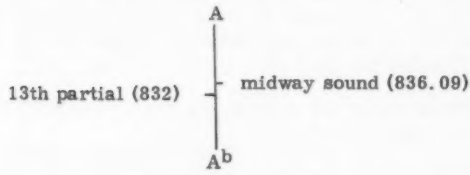
$512 \times 8/5 = 819\ 1/5$

and A would have a frequency of

$512 \times 5/3 = 853\ 1/3$

and $\sqrt{819\ 1/5 \times 853\ 1/3} = \sqrt{699,050\ 2/3} = 836.09$

Since a sound midway between our just A^b and our just A would have a frequency of 836.09, and our 13th partial has a frequency of only 832, again it is obvious that the latter is closer to a just A^b than to a just A:



Conclusion: We have examined the Pythagorean, meantone, and just temperaments with a view to discovering the possible sources of the erroneous F-A and F#-A combinations still used in notating the harmonic series. We eliminated Pytha-

gorean temperament as the source of either one of these because it demanded an F-A^b combination. We concluded that meantone temperament was the possible source of the F#-A combination. We had half expected to find just temperament the possible source of the F-A combination, but, as we have just proved, it was not. In just temperament, as in equal temperament, the 11th and 13th partials of C are closer to F# and A^b respectively.

In the heyday of meantone temperament, the notation of the 11th and 13th partials of C as F# and A respectively was justifiable. Today, of course, it is not.

There has never been any justification for notating these two partials (in combination) as F and A. In this day and age of equal temperament these two partials should always be notated as F# and A^b.

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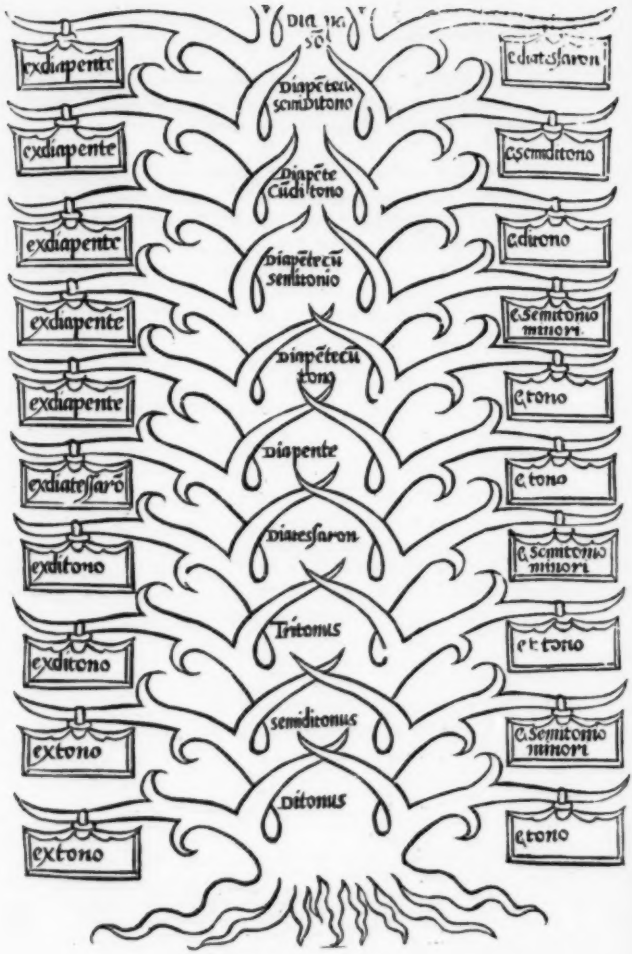
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FORUM

ANDRES BRINER

Paul Hindemith recently made his own German translation of the lectures he delivered at Harvard University ten years ago and which were published in 1952 by Harvard University Press under the title A Composer's World: Horizons and Limitations. While the German version (Komponist in seiner Welt: Weiten und Grenzen, Atlantis-Verlag, Zürich und Freiburg 1959) retains the title and as a whole clings closely to the original text, it contains a passage newly written, one which proves to be of considerable import. This must have been prompted by Hindemith's unabated interest in the full nature of "tonality," and although it does not modify the composer's stand on the issue, it nevertheless helps to bring out the full implications of the composer's strictly tonal concept. Among the overtones of the passage there rings a note of concern about the preoccupation of most composers of the younger generation, in

Germany and Italy especially, with the "atonal" techniques of Webern's followers. Thus, Hindemith observes in his Vorwort zur Deutschen Uebertragung [Preface to the German Translation]: "...from the tradition in which we grew up, little is left today. The tendency towards sensation, the rapid exhaustion and overestimation of sonority and everything technical, play a role far too important. Thus many persons, and not only the opponents of new developments, are concerned about the future."

We now offer a translation of the main part of the section inserted in the fifth chapter (German edition p. 106-108). The chapter, as the reader will recall, contains in its earlier parts a fundamental exposition of sound as the working material of the composer, including (in paragraph 2) an explanation of the overtone series and (in paragraph 3) an explanation of the roots of chords and combination tones. Paragraph 4 introduces musical meter and harmony, and from this the author proceeds to the laws governing the succession of chords. The section in question starts after the next to the last sentence of the fifth paragraph of the chapter (English edition p. 81).

Hindemith writes:

The concept of "tonality" and its appropriate treatment appears to be so diversified today as to lack any unified basis. Some basic observations upon this issue may therefore prove useful.

First, on the nature of tonality. At this point of the discussion, it should be clear that tonality is to be understood as a melody projected into a larger musical area. The individual harmony within a tonality corresponds to the individual tone within a melody. The melodic step from tone to tone within the melody has its counterpart within the tonality in the succession of harmonies. (As a precautionary measure, one perhaps not really necessary, I draw attention to the fact that a strict distinction has to be made between "harmony" and "tonality," a distinction similar to that on the "lower level" between tone and interval. Even in some commendable writings these two terms are not distinguished sufficiently, this probably being one of the reasons for the widespread confusion of concepts.) The intervals of a melody assume a harmonic quality, whereby the tones differ in harmonic value. One of the two tones constituting an interval will always try to dominate the other; this test of force necessarily pervades any melody and does so basically independently of the accompanying (tonal) harmonies. Such a dynamic competition shows up first within the relationship of

neighboring tones, then spreads to points of greater importance (tones conspicuous by their special position within the range, by their length, articulation or repetition).

Corresponding conditions exist within the tonality. The competition for domination becomes evident as one harmony is followed by another, whereby the main determining factors lie in the formation of the individual harmonies: in the vertical distances between the tones, in the number of tones superimposed, and in the perceptibility of the root. To these relationships must be added those between tones of special prominence, that is, extreme positions within the range (including special characteristics of the disposition of intervals within the range), features of conspicuous duration, articulation and re-establishment of harmonies (succeeding different harmonies). It must be made clear that the determination of all these melodic and tonal characteristics does not lie within our will power. What we were describing is the natural way of mutual behavior between tones within melodies and between harmonies within tonalities. Even our interior experience of music follows, mirror-like, such a continuous establishment of relationship between the present and the past. The only choice left to us within this process is the following: we may listen carefully or lazily, we may be understanding or stupid —or we may even prefer only to have acoustical sensations pass before us.

Thus, the common, vacuous understanding of tonality as the area of major and minor tonalities recognizes only a sector of tonality [Ausschnittstonalität], one of rather limited possibilities. The same is true for the understanding of tonality as the area of the modal scales. It is inconsistent to speak about "extended tonality" [erweiterte Tonalität] upon leaving the area of major and minor, since this term still refers to major and minor as the (only) basis of tonality. In fact, tonality exists only in the fully comprehensive form we just described.

Regarding the embodiment of tonality in a composition, the one and only question that follows from the foregoing concerns the ways in which and the extent to which the possibilities of mutual harmonic relations are to be realized. In accord with the nature and aim of the composition, the composer will have to make significant use of the antagonist behavior of the point of special prominence we mentioned — from conspicuous positions within the range to re-establishments of harmonies. The rules that can be designed to govern the compositional work have to show the same comprehensiveness as those

governing the creation of melody. (It need hardly be mentioned that the term "melody" is to be understood in its broadest application. It should cover the soprano voice in Bellini's Casta Diva aria as well as the highest tones of an arrangement [Anordnung] by Webern — tones that come off as a melody.)

It is understood that there are both simple and complicated relations between harmonies — according to the way in which the points of prominence are related. Compared to the already verified degree of affinity between the tones of an interval, the degree of affinity between the participants in a tonal relationship is necessarily more than a thousand times higher. It has recently become a habit with composers to use almost exclusively the more complex relations and to avoid the simpler, more easily manageable relationships. This trend seems logical in view of the relatively small amount of exploitation of these complex relationships in the past. Yet, composers nowadays believe that in this way they have escaped the laws of tonality and reached an area of unlimited freedom. It is the awareness of the natural origin of melodic and tonal sequences that makes such a belief appear rather childish. What is held to be "atonality" necessarily turns out to be another aspect of tonality — the only difference being that the "atonal" work fixes the sequences in another of the various corners of the full tonal area.

EDITOR'S NOTE: We wish to thank Schott Söhne, Mainz, for permitting us to publish Mr. Briner's translation.

* * *

FORUM

NORMAN CAZDEN

Musical pitch relations can be measured objectively and accurately by such means as M. Steiner's slide rule*1, and time relations can be measured by means of a stopwatch or metronome. Both pitch and time may be transcribed directly in visual form, most successfully through the universal sound graph technique of Charles Seeger*2. These developments have unprecedented value for ethnomusicology, and for scientific analysis of performance practice.

In principle, what is measured or visually represented by such methods is not, strictly speaking, music, but rather musical data considered as concrete acoustical phenomena. Because they are abstracted from music as an art, because they are acoustically objective, these measurements and representations are not restricted to the peculiar requisites of any par-

ticular musical system. Hence, they may serve to reveal many of these very requisites through comparison with objective standards.

Both Gerson-Kiwi and Seeger accordingly demonstrate the special usefulness of their methods in conjunction with ordinary staff notation, among others. Wisely, neither calls for the abandonment in practice of current notation systems. I would judge that more is implied in this than an expedient or presumably temporary tolerance of a notation proven obsolete. It is recognition also that the historically evolved forms of European staff notation, however inadequate from a rigorous scientific viewpoint, contain certain unmistakable and irreplaceable links with the characteristics of their referent musical system, which they express validly and for which no abstractly logical or universal symbolization could substitute.

In this sense, the achievements of a universal graphic notation and of easy techniques for precise tone measurement provide deeper insight into the processes of that musical system, among others, which staff notation more or less accurately registers. Objective measures thus become critical tools for analysis of that system. As a by-product, they may also inversely direct attention to a general theory of empirical music notations as systemically oriented communications codes.

Musical notations proper, as distinct from objectified acoustic analyses, have developed along two fundamental lines, which may be termed the conceptual and the executive. The conceptual principle leads to systems of visual symbols which represent the musical tones — and/or their conventional systemic relations — which the performer is to render. The executive principle leads to systems of symbols which represent instead how the musical tones — and/or their conventional systemic relations — are to be rendered. The conceptual principle is pre-eminently vocal in origin, while the executive principle originates in instrumental music.

For music to be sung, it is not possible to set down, in determinate signs bearing psychological correspondence to the processes of vocal production, just how a given musical tone or interval is obtained. Perforce, such signs must therefore represent not how, but what is produced. The tone or relationship itself is indicated directly as a concept, which the singer is to match. The concept is of course conditioned and defined by experience with a musical system, and hence in objective view its symbol must remain not only arbitrary but in-

complete It necessarily suggests and comprises far more than its literal definition indicates: conventionally appropriate timbre, duration or intonation values, for example. The evident gaps and imprecisions of information conveyed by conceptual notations are thus largely compensated by hidden references to an already known performance practice. Such systems have therefore both the faults and the virtues of shortcuts. They are practicable on a short historical time scale, in that their principal service is mnemonic aid. Unfortunately, a set of mnemonic aids of stylized and limited scope is of no use whatever unless its complete frame of reference has been maintained in more or less continuing traditional practice. Conceptual notations for musical systems no longer practiced are thus inherently untranslatable, save in the degree to which their references have been described in objectively measurable form. Thus the ancient Greek alphabetical notations can be read today, but not the chironomic neumes of 10th century western Europe or the perhaps earlier ekphonetic notations of Armenian, Byzantine and other eastern records.

Executive or instrumental notations do not symbolize what musical tones or relationships are to be sounded, but show rather how the sounds are obtained. While arbitrary symbols may be devised to this end, the principle lends itself most readily to schematic diagrams representing specific instruments. Any such symbolization is thus automatically limited to a particular instrument, and further to a particular tuning, fretting, spacing of finger holes or arrangement of mechanism; while for many instruments, such as horns, none is possible. Within these limitations, instrumental notations serve as practicable shortcuts for communication, more overtly dependent upon assumptions of an already known performance practice, though somewhat less confined to service as a mnemonic aid. If it is possible to obtain or to reconstruct the instrument for which such a notation was devised, some degree of translation of its notation becomes possible, even if the musical tradition is otherwise lost.

Typical conceptual or vocal-style notations are alphabetical or syllabic systems. Typical executive or instrumental notations are tablatures or fingering charts. The common guitar fret-chart is an executive notation, specific for a guitar with six strings in conventional tuning, while the lettered chord symbol that usually accompanies it today is conceptual and can consequently be rendered on any suitable instrument.

Staff notation may be described in these terms as a special

combination of the conceptual and executive notation principles, with the immensely significant addition of a schematic time-scale. Staff notation is fundamentally conceptual in origin and began as a mnemonic aid to vocal music. Only thus can it be explained how its earliest unilinear and non-mensural form could have been of service. However, staff notation adopted also the characteristic method of the executive principle in the form of a spatial diagram, initially representing the single string of the monochord. But, since the time-span relations of the verbal texts for European vocal music were already fixed along a horizontal axis read from left to right, development of the staff principle required the rotation of string-fret diagrams by ninety degrees, so that pitch relations came to be shown along a vertical axis. This rotation is equally in evidence in current instrumental tablatures. For example, the guitar fret-chart shows the strings in vertical position and the frets as horizontal. Only in this way can the charts be used parallel with staff notation, song texts, or more commonly with both.

Staff notation began, then, as a special development of mnemonic aids for rote-learned vocal music. Its distinctive principle is spatial representation of conceptual pitch level along vertical ordinates, combined with a stylized, partly spatial but chiefly syllable-measuring representation of conceptual time along a horizontal abscissa. The peculiar advantages of the system result from the connotative linkage of vertical space in the visual field with musical pitch in the auditory field — which is by no means either so difficult to grasp as the sol-fa enthusiasts insist, or so mystically immanent as some psychologists have claimed — and from its radically new potential for simultaneous symbolization of time as a measurable dimension of music. It is indeed a sound-graph in miniature, and vastly superior to its precursors. Though fret-charts and finger-hole charts on the one hand, and alphabetical or solmisation systems on the other, continue in relatively marginal use, they have largely been displaced in western music by staff notation, and serve chiefly as accessories to it.

For all its well-known deficiencies, staff notation has proven its generality and serviceability for the representation of instrumental and vocal tones within fair limits of accurate reference for pitch and time relations within the musical system which gave it birth. Human frailties taken into account, it has proven remarkably flexible and adaptable to historical change in that system. The history of European music since the 10th

century would have been quite different without it, and reliable record of that history virtually impossible. Yet, it must not be forgotten that it is a systemically conditioned mnemonic aid and not a scientifically valid, intrinsically logical, fully objective or universally applicable communications code, such as Seeger's sound graph promises to be.

Staff notation has of course its own history*3, and much of that history must be called upon to explain features that in sober view appear incomprehensible. The resistance of the system to rational printing methods is symptomatic of its problems. Some ingrained features of staff notation are mere orthographic accidents, as witness the freezing into permanent practice of a particular florid pen-letter G as the G clef symbol. Some features reflect vestiges of obsolete meanings, as does the metrical signature C, which some American and English schools persist in interpreting erroneously as signifying "common time." The system as a whole shows continuing accretion and refinement, for example, the downward roll sign; and considering the drastic conservatism imposed by print standardization it shows surprising latitude in detail. There have been retrogressions as well, for example in the relatively recent neglect of the very useful C clef, and the reintroduction of color-coded notes and even of keyboard charts as if these constituted modern educational advances.

Fundamental criticism of the theory of staff notation lags, though proposals for revision of its details and complaints about its more trivial archaisms have accompanied it since its inception. Most useful reforms have been introduced without fanfare by thoughtful composers and editors, an example of the former being the score notation of wind instruments at concert pitch, using F clef and C clef where convenient, and of the latter the elimination of the quite superfluous syllabic tailing of vocal parts. But unless guided by the closest professional contact with notation experience, proposals for notation reform tend to become speculative toys for cranks, like those who periodically rediscover a non-diatonic staff*4, though knowing nothing of non-diatonic music.

But many attempts at revision of staff notation relate neither to fundamental criticism of its principles nor to tinkering with its details. They arise rather as logical corollaries to desired changes in the musical system to which the notation refers. Thus, in negative fashion, criticism so motivated may expose the unsuspected degree and manner by which current notation practice reflects, not an abstract solution for trans-

cribing music into visually communicable patterns, but rather the precepts peculiar to traditional tonality. So Yasser*5 quite reasonably finds a 3 line and a 10 line staff to be proper notational accessories of his hypothetical infra-diatonic and supra-diatonic scales respectively, for all that in this notational aspect as in his general theories he seems invariably the prisoner of the very concepts he proposes to change. Cavallini*6 summarizes various ingenious adaptations of common accidentals for the notation of music using quarter-tone or sixth-tone divisions. Cowell*7 speculates on the potentials of differentially shaped noteheads for showing rhythmic proportions other than duple, and devises neat symbols for keyboard clusters. It is a commonplace that twelve-tone technique presupposes rejection of the enharmonic differentiations shown in current notational forms, so that the writing down of music employing this technique involves today many a painful compromise. Krenek*8 quite properly regards even the denomination of diatonic intervals as inapplicable to this technique, though by mistaking his hypothesis for a self-sufficient universal truth he cannot conceive how diatonic terminology came to be.

Thus efforts to adapt staff notation to the exigencies of music that departs from traditional tonality show an explicit, though in each instance a partial, recognition that many accepted features of that notation are not justifiable on rational grounds, but solely as resultants of a particular systemic practice. Because such features must consequently be revised or discarded as soon as alternative musical precepts are employed, such proposals in their sum also serve as critical tools, helping to lay bare the nature of the musical system which has effectively determined the forms of its notation.

If we pursue the above indications from the standpoint of a general communications theory, staff notation throughout its historical development is seen to exhibit a fundamental dichotomy. In some directions and in some measure, staff notation is a logical if imprecise visual symbolization of music which presents pitch and time relations of tones in a modified spatial graph, fortunately admitting also a wide variety of such useful accessory symbols as dynamics signs, indications for manner of performance, direct verbal instructions and others. The degree to which highly artistic performance of music has been achieved through reliance primarily on learning from its notated forms, though secondarily also on the less determinate traditions of performance practice, testifies sufficiently to the considerable success with which staff notation can register

and transmit musical information, and it would be a mistake to underestimate this success.

But in many other directions, as numerous critics have not failed to observe, staff notation is highly irrational, contradictory, archaic, arbitrary, and distorted. While some of these characteristics may be remediable by judicious adjustment of its details, in historical perspective it must be recognized that the features criticized represent nevertheless the accumulated thought of generations of wise and well-motivated musicians. This suggests that at least some of the observed defects are inherent; that they do not arise from some strange obtuseness of men, nor yet entirely from accident or carelessness, but from the inseparable connection in practice between notation and the musical system which it more or less adequately reflects. That musical system is not thereby discovered to be irrational, though both the system and its notation may appear so if some other system be assumed. The traditional musical system is rather better defined, better understood, through an examination of those otherwise irrational characteristics which turn up, even though transformed, in its accompanying mode of notation.

As a communications code, therefore, musical staff notation may be seen objectively, on the one hand, as a logical set of symbols devised to convey within certain limits of accuracy some types of related information; and on the other hand, as an accumulation of stylized irrationalities, arising in part from sheer failure to achieve its purposes, and in part from characteristics of the information system itself which are extraneous to or incommensurable with abstractly logical requirements. In this general sense the historical development of staff notation has been characterized by an increasing divergence between its rationality as a communications code and the irrationality imposed by its complex and incompletely understood referent.

Useful criticism of staff notation, history of its particular forms, or well-considered moves to revise or reform it in a given direction, would in this view need to start out with recognition of this general rational-irrational dichotomy. I do not propose here to enlarge on such criticism or on historical study. Neither do I wish to tamper with current practices of that system, difficult as such a resolve may be for a musician. My interest here lies rather in theoretical exploration of the implications of communicative potential presented by a code formed and distorted in the special service of traditional

tonal music.

More specifically, I offer here not so much an analysis, as a dramatic demonstration of the terms which such analysis requires — this in the hope that such demonstration may stimulate deeper consideration by musicians of the nature of their common written language, and thus indirectly of the nature of the language itself, and in the hope that it may prove of further interest, if not of practical benefit, to those concerned with communications theory in general. And though I advocate no more than the recognition of phenomena of this level of abstraction, it is possible that the demonstration may suggest additionally certain practical opportunities for composers.

This demonstration turns upon the possible use of musical staff notation as a non-musical communications code, meaning for the communication of information wholly unrelated to music. For, if our judgment of the general rational-irrational nature of staff notation be valid, it follows that by means of this notation can be attained that elusive ideal of communications codes, the perfect cipher. By the perfect cipher we mean a technique of communication by which information can be conveyed to selected individuals supplied with the cipher key, but which cannot otherwise be deduced.

Now, musical ciphers are not unknown. They constitute in particular a significant area of interest for scholastic minded musicians of past centuries, and they have occasionally served more recently for musical games. Such examples as the Missa Hercules of Josquin Des Prés and the "Sphinxes" in Robert Schumann's Carnaval will come readily to mind. But such ciphers do not answer to the purpose. They arise from musical terminology, and are thus not generally adaptable to a non-musical content. They are metaphorical and cabbalistic rather than inherent in the properties of the notation which forms their vehicle. And they answer to casual curiosities rather than to the intent of the information conveyed. When it is found that the two strong chords opening the Carnaval happen to have the notes named sf on top, the clever stroke is appreciated; but a private musical joke does not constitute a comprehensive cipher system. Musical ciphers also occur in such forms as puzzle canons, but the solutions of these are entirely musical, and they offer no formula for the encoding of non-musical information.

What conditions must this demonstration meet? The first requirement of a communications code is obviously that it com-

municate. The cipher must therefore be amenable to accurate and preferably quick translation by anyone reasonably trained in reading ordinary musical notation and provided with the cipher key. A second requirement is that it be capable of registering any type of information that can be formulated in words. A third requirement is that it can be composed and set down without difficulty by anyone capable of reading it and provided with the cipher key. Finally, though this would not be required for the stated purpose, it would be desirable if the result might appear to have some musical use and relevance.

But to constitute the perfect cipher I envisage, my demonstration must fulfill also the condition that its key, and hence any translation, cannot be deduced, even if cipher communication is suspected. Now it should be fundamental to communications theory that no practicable code translatable in a known language can be constructed by the mind of man that is not inherently susceptible of eventual deductive translation from an adequate sample. Stated otherwise, if something be communicable at all, any consistent and complete procedure for conveying it that is conceived by one person or group can be duplicated eventually by the thinking of another. The perfect cipher is thus a theoretical impossibility, given sufficient time. Furthermore, ciphers may be analyzed by machines, which incidentally serve also to reduce solution time. And considering just the presently attained marvels of electronic computers, it would appear rash to suggest that any communications code providing sufficient data could not be subject to swift demolition.

How, then, could a message coded in musical notation escape eventual exposure? Simply through the special combination of rational and irrational aspects to which I have drawn attention. Staff notation seems sufficiently rational to make communication possible to the desired degree of accuracy, while at the same time sufficiently irrational and arbitrary to defy deductive analysis. Logical constructions by one mind can indeed be duplicated by another, but suppose the logic is quite askew, or suppose it is rooted in a wholly extraneous matrix such as is constituted by a musical system. Again, elements of a notated cipher, however many and whatever their form, can presumably be factored and programmed for machine analysis, which analysis will in theory solve for ever so many unknowns. But just how are elements to be identified and interrelated in an irrational system? Suppose at least some of them to be unidentifiable unless the whole complex is al-

ready known; suppose at least some of them to be irreducible to quantitative or graphic form; suppose some to be incommensurable even as variables of the same order; suppose they are ambiguously intertwined without necessary dependent function. Programming of such a complex of variables is frustrated, and Illiac*9 remains with insufficient data. The mathematician can perhaps interpret the diatonic scale as a skew curve, but how is he to express the relationships among a quarter rest in the bass, an augmented sixth on an upbeat, a two-note slur and the Pythagorean comma?

It might be judged in this light that musicians could penetrate a notated cipher most readily, since they are familiar with its terms. This demonstration is therefore presented to an audience of especially qualified musicians to test my conviction that the opposite may be predicted. For, the musician is impeded by the very process through which he learned notation, by a sort of extreme case of proofreader's myopia. He cannot divest himself of the entire set of assumptions, many of them hopelessly lacking in outward sense, which underlie his by now automatic responses. To the degree that the musician sees music on his page he cannot see notation as such objectively. It is well known that the non-notereader makes the best page turner at a concert. Here non-notereading would also not serve, since the musical referents are germane.

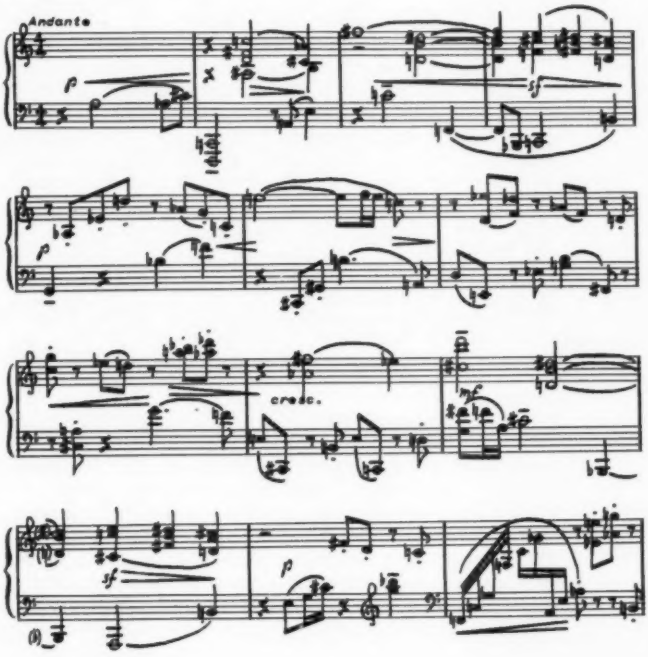
Some may wonder at first how the proposed cipher for non-musical communication could have any value as music, when music is not its prime object. But recent experience surely suggests that apparent absence of a properly musical objective or motivation does not of itself obviate consideration of data as music. I need not cite concrete examples now so familiar. For all that its admitted purpose be a non-musical communication, the musical value of a composed cipher message may well match that of any composition founded on extra-musical constructions, whether arbitrary or random. It may even prove more indicative of musical talent than some using procedures currently practiced, since it is less limited in principle and embraces a fuller range of musical criteria.

Such a result would but confirm overtly what many have long suspected to be the ultimately non-musical inspirations as well as the non-musical consequences of construction-oriented composition. Frank avowal along these lines might lead not only to refreshing contributions to musical aesthetics, but also to superior methods. For it can be predicted safely that for at least equally artistic results, the notation cipher is less

pretentious, easier to compose and less time-consuming. Thus if adopted in practice, the cipher principle may open up a new field of employment for composers, especially those already adept at handling serial, adventitious or other formulas, thus enabling them to become more useful members of society.

Demonstration of the cipher method will proceed as follows. Example 1 is a communication of a non-musical message by means of ordinary staff notation, with neither the cipher key nor a translation provided. If this example can be deciphered the demonstration fails at once, and it becomes needless to continue further. Example 1 will otherwise serve as proof for those following.

Example 1



Example 1 (continued)

But failure to solve Example 1 within any finite time would not prove positively that it is insoluble in principle, as is maintained. Hence Example 2, which is another message employing the same cipher, with the translation given, but not the cipher key. If the cipher is at all amenable to deductive solution in theory, it should surely be possible, with the translation of Example 2 as check, to derive its encoding method; and this method should produce a solution for Example 1. Achievement of such a solution would be a crucial invalidation of the demonstration.

Example 3 is a third communication employing the same code, with both the translation and the cipher key provided. By its means, the method used for Example 2 is made clear, and the translation of Example 1 becomes possible.†

Turning now to the demonstration, Example 1 is a musical composition which conveys a non-musical message. Its solution remains a problem for the reader to solve.

Example 2 is a musical composition which similarly conveys a non-musical message, its translation being readily accessible: it is the opening of Lincoln's Gettysburg Address. Derivation of the method by which this known message is encoded should make possible the translation of Example 1, else the cipher must be admitted to be inherently insoluble.

A question may arise at this point as to whether one and the same cipher code is used in the two examples above; with the further question as to whether, following from my exposition, more than one method may exist for the encoding of non-musical information by means of musical notation. Experience cannot as yet show whether the number of possible codes of this order is infinite, but it can be established that this number is very large. Furthermore, while the cipher key to one such code might provide hints as to the possible criteria for solution of another such code, it would not in fact make the latter's derivation possible. Admitting the theoretical multiplicity of possible codes of this nature, I state unequivocally that the particular code employed for my three examples is identical, and relatively a simple one.

†EDITOR'S NOTE: Example 3, using the same code as the others but with both a translation and its method of solution provided, together with the solution for Example 1, will appear in a subsequent issue of this journal, along with acknowledgment of any successful solutions of Example 1 that may be received in the interim. All three examples are reproduced in Mr. Cazden's own hand.

example 2

example 2

notes

1 GERSON-KIWI, EDITH
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BOOK REVIEWS

THE RHYTHMIC STRUCTURE OF MUSIC
by Grosvenor W. Cooper
and Leonard B. Meyer
UNIVERSITY OF CHICAGO PRESS, 1960. 212p., $6.00

REVIEWER
ELLIS B. KOHS

The principal thesis of this provocative book is that musical form, properly apprehended, is a macrorhythm or Gross-rhythmik, to use the term employed by Alfred Lorenz in his monumental study of Wagnerian forms. This will come as a surprise to those who have always thought the larger forms derived primarily from motivic and thematic elements. The impartial observer of both schools of thought cannot help note that there is a tendency on the part of many creative theorists to construct all-embracing theories to describe a musical world of never-never land consistency and perfection, where there would be no unexplainable practices. These theories might have been acceptable in the pre-Freudian world, but it is difficult to accept them today in the light of our knowledge of man and artist as something less than a perfectly consistent and rational being.

In this writer's view, a non-partisan approach to theoretical approaches is, in the long run, the soundest. In fact, many truths may be revealed by theorists of quite contradictory viewpoints, and the student of theory is well advised to synthesize elements drawn from a variety of opposing theories rather than to adopt in toto the viewpoint of only one theorist. It has been said that analysis has value primarily for the person making the analysis, and only secondarily for the person reading it; it is equally true that a point of view, carefully formulated, has more value for the person who arrives at it than it has for someone who only knows about it.

The authors, aware of the pitfalls of absolutism, are careful to state that several interpretations of a given musical passage are possible. For example, they indicate (p. 10, 84) that "analysis is an art rather than a science," that a rhythmically ambiguous passage might be interpreted in three different ways (p. 34-35), and that "sensitive, well-trained musicians may differ" in calculating what in any particular instance a rhythmic grouping may be (p. 9). There are occasional examples of double or alternate analysis in support of this attitude.

The book consists of 7 chapters of text, in which there are many analyzed illustrations, and an 8th chapter or appendix containing 2 extended musical examples analyzed on several architectonic levels. Some of the analyses are quite detailed, for example the study of the opening 8 measures of Mozart's Jupiter Symphony, which covers all of 8 pages (p. 117-125).

The work is intended to serve as a text, or companion text, in harmony, counterpoint, interpretation, or form classes, and as such includes at the end of most chapters a number of exercises in analysis and composition. It proceeds from a discussion of rhythm on the more obvious lower architectonic level through more complex rhythmic structures to a consideration of the larger forms. There are individual chapters on rhythm versus meter, rhythmic mobility versus rhythmic tension, rhythmic continuity and development.

Some of the attitudes, ideas, and the literary style that characterize Meyer's Emotion and Meaning in Music are evident in this book too. Perhaps the most important concept carried over from the earlier study is the notion that musical structure at any level is not a fixed thing that exists, gradually perceived as our ear takes it in (compare the eye movements which gradually reveal a painting that does exist complete at

any moment in time), but rather it is an act of unfolding, an experience of becoming rather than of being. Musical comprehension thus involves not only immediate perception, but simultaneous revaluation of prior events and revised expectations regarding future events.

Some of the concepts which are elaborated by Cooper and Meyer are perhaps not new, but many of them are stated more clearly or in more detail than in other texts. The more important of these are: the difference between syncopation, suspension and tie; the use of consonance as a dissonance and vice versa; the accented silence; theme versus subject, motive, and melodic idea; accent versus stress; and the concept of rhythmic inversion.

Rhythmic groupings are described by terms generally associated with prosody: iamb (⏑–), anapest(⏑⏑–), trochee (–⏑), dactyl (–⏑⏑), and amphibrach (⏑–⏑). It is not altogether clear why the spondee (--) is not included, nor why the unnamed ⏑–⏑ is considered an overlapping of trochee and iamb rather than as a separate independent pattern. A further difficulty is that this terminology makes it impossible to distinguish between ♩ 𝅘𝅥𝅯 and ♩.𝅘𝅥𝅯, both of which would be labelled trochee by the authors. (See further, paragraph 11 below.)

Despite the very evident thought and care that has gone into the preparation of this book, a number of remarks or statements seem highly questionable if not entirely erroneous. For example:

1 "Tempo...is not itself a mode of organization....It is not an organizing force." (p. 3) It is difficult to reconcile this statement with phenomena such as the slow-fast-slow-fast pattern of the Baroque sonata or the slow introduction of a sonata-allegro movement.

2 "Meter is the measurement of the number of pulses between more or less regularly recurring accents." (p. 4) Meter may be a measurable organization of pulses; it surely is not itself the measurement of the pulses.

3 The term "prepared dissonance" (p. 21) hardly seems applicable to any note in the unharmonized melody in Ex. 30b.

4 The analysis of Ex. 31 shows an upbeat of over one measure leading to a downbeat of half a measure, but it fails to indicate the very evident fact that the odd-numbered measures are in effect upbeats, the even-numbered measures downbeats.

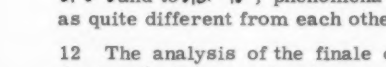
5 The 8 measure introduction to the Scherzo movement of Beethoven's Ninth Symphony is described (p. 79) as having "no melodic shape" because it "merely moves through the triad with the groups so separated temporally that they remain discrete units." This will be news to Rudolf Reti, and is a remarkable volte-face in view of the obvious influence of Schenker elsewhere in the study.

6 The 8 measures referred to in par. 5 above, (Ex. 94), include 4 distinct ♩. ♫ units which the authors view as forming 3 rhythmic groups, all upbeats. Since these 8 measures clearly comprise a distinct section as introduction, at least one of the 3 units should be a downbeat, probably the last one since it is the only one which is unambiguously 3 measures long and therefore is the weightiest.

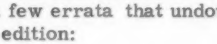
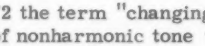
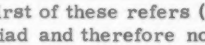
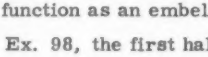
7 On p. 83-87 an A B A form, in which each of the 3 sections is 8 measures long, and therefore obviously balanced, is ingeniously analyzed as binary in structure. This feat is accomplished by considering the B section as a large anacrusis to the following A; the B A group is then described as a "single impulse." It would appear that the authors fail to distinguish the type of interdependence found in this example from the thematic antecedent-consequent type of relationship one finds in a period, which is truly a single impulse (both thematically and rhythmically). There is a similar problem in the familiar A' A" B A" form (4+4+4+4 or 8+8+8+8), which is neither binary nor ternary but a mixture of the two; for here there is a thematic unity in the first pair (A' A" is probably a period) that is lacking in the second pair. The authors assume that rhythm is necessarily a more potent factor in the determination of form than is thematic material, instead of considering rhythm as only one among several possible form-determining factors, none of which are more important a priori than the others.

8 It is stated (p. 145-146) that at the end of measure 12 of a quoted traditional tune, we know that it will be followed by a repetition of the opening 4 measures, for "stylistic reasons." Since there are many tunes, hymns, anthems and the like that have no formal repetition of A after a B section (America, The Star Spangled Banner, etc.) there is little foundation for such an assumption.

9 The larger rhythm of the Chopin Prelude quoted in full on p. 185f. appears on p. 152 (not p. 159, as stated on p. 185), and the A B A' Coda structure is described as a three-part form in which part I is A (upbeat), part II is B A' combined (downbeat) and part III is the Coda (upbeat). This is in obvious con-

flict with the thematic three-part form which most musicians would regard as having been uppermost in the composer's mind when he conceived the work. If one must reconcile the thematic and rhythmic structures, it would be more logical to view the form as  so that B is heard as a large weak beat, the Coda as a prolongation of A'. Of course this would result in the rhythm – ⏑ – which (as noted above) the authors regard as non-existent.

10 In a book so comprehensive and historically oriented it is surprising to find no mention of the rhythmic modes, or of the isorhythmic motet in which rhythm plays so important a formal role. Nor is there any attempt to deal with asymmetrical structures such as Latin American and Bulgarian rhythms (3+3+2, etc.).

11 One questions the reason for describing as an iamb (⏑ –) rather than as an anapest (⏑⏑ –) (p. 65);  as the rhythmic equivalent of – ⏑ – ⏑ (Ex. 79); as trochee rather than dactyl (Ex. 49). In Ex. 140 refers equally to  to  and to  , phenomena which the musical ear hears as quite different from each other.

12 The analysis of the finale of Brahms' String Quartet in A minor (p. 81) describes the apparent cross-meter as 6/4 + 3/4 when it should be 2/4 + 2/4 + 2/4 + 3/4 or 3/2 + 3/4.

In addition to these matters involving difference of opinion, there are a few errata that undoubtedly will be corrected in a subsequent edition:

1 P. 17, there should be no staccato marks in the pizzicato cello part.

2 P. 58, substitute "maman" for "mamam" in the title of Mozart's well known variations.

3 On p. 72 the term "changing-note" is used to describe the same type of nonharmonic tone that is called "auxiliary" on p. 126. The first of these refers (in Ex. 88) to a tone that is the third of a triad and therefore not nonharmonic at all, despite its obvious function as an embellishment.

4 P. 83, Ex. 98, the first half-note should be dotted.

5 P. 89, the statement that "during the Middle Ages and the Renaissance, there were no bar-lines at all" is not true. As Apel points out and illustrates with facsimiles in The Notation of Polyphonic Music, 900-1600, bar lines were used in Renaissance keyboard music, and in keyboard and lute tablatures as well.

6 P. 185, the reference "See text p. 159" should read "...151-2." Additional reference should be made at the same place to the text on p. 126.

7 P. 152, the mysterious "4" to the left of the first diagram refers to the fourth level of analysis on p. 185. A footnote is needed to make this clear.

8 P. 203, reference to the diagram on p. 161 is needed, and the figure 109 under "Development" should read "189."

9 In the index, p. 206, add "defined, 29" under "Inverted groups"; and on p. 210 "Chapin" should read "Chopin."

This is a small number of errors and problems in a book of such vast scope with many design and printing problems. The authors have made a significant, courageous and, on the whole, a successful attempt to deal with a very controversial and neglected subject. The students to whom they address themselves will be stimulated and provoked to think for themselves about problems of whose very existence they may have been only dimly aware.

In teaching harmony, counterpoint, form, and composition the writer has long been aware of the insufficient attention students give to rhythm and rhythmic organization, the expressive values of rhythm, and the relationship of rhythm to other elements of music. He is sure others have had similar experiences and will join him in considering this book a valuable adjunct-text or reference. Certainly no one who takes the time to read it will emerge from the experience unchanged or unmoved.

COUNTERPOINT, A SURVEY
by Edmund Rubbra
HUTCHINSON UNIVERSITY LIBRARY, LONDON, 1960.
124p., 12s 6d.

REVIEWER
JOHN A. RITCHIE

That this small book should achieve what its title claims is a triumph for the author's literary style and the clarity with which he is able to present ideas. Far from being a text book in the accepted sense it should be read by every student of composition, and acted upon if only to resurrect the ancient and honorable practice of copying out other composers' scores.

Planned in such a way as vaguely to suggest a chronological approach, the text confines itself in three chapters to the contrapuntal forms and in three others to a more general examination of textures. Opening with the latter, Mr. Rubbra is at pains to have us clearly aware of the significance to the composer of the rhythmic independence of parts, the difference between accent and note value, the basic importance of the three-part texture, and the overall historical assertion that "there has been no steady and undeviating evolution of contrapuntal method." Together with this and incidentally he traces the early development from unisonal composition to multi-part textures. Postulating the extreme norms of organum, "a texture of a slow-moving lower part coupled with ornate upper parts" and conductus, "a texture of two or more parts that have no rhythmic independence," the author points to the fugue and the chorale as later manifestations of this textural dichotomy.

On the canon, Mr. Rubbra gives advice resulting from the analysis of well chosen examples. A gentle rebuke is administered to those moderns who label the ratiocinative devices used in the manufacture of their music. Cancrizans, he contends, is "a purely mental concept, as music can never do anything but go forwards." New light is thrown on the resources of tonality as opened up by flexibly used intervallic relation-

ships. In this connection the technical basis of Holst's ingenious "Lovely Venus" is most lucidly demonstrated.

Twenty pages are devoted to the survey of fugue. There are few generalizations because, after all, so few can possibly be valid where fugue is concerned. It may surprise readers to know that over half the chapter is occupied with music of this century. Similar treatment is accorded the chorale prelude, the passacaglia, and the chaconne in an essay which places much emphasis on the canto fermo technique as a procedure in composition.

The later chapters, headed Free Counterpoint and, oddly, Counterpoints, besides giving the author an opportunity to coalesce his argument also offer the best starting point for a discussion of some of the many instances of his crisp and authoritative thinking. It is not unfair to quote a few, because frequently their context is not obligatory to a full understanding:

> The true composer is one who is continually hoodwinking the purist by utilizing forced changes in his material to the advantage of its structural development.

> One of the most important things in composition is to avoid competing claims in the music.

> Complexity in counterpoint is aesthetically right only when it has been led up to by simpler strands.

Contentions like this abound in this volume; but they do not possess the arrogance of text book utterances nor the meaninglessness of a collection of composers' hints. Rather are they observations based on experience, emerging forcefully as logical deductions made from aptly selected examples.

Perhaps it is expecting too much from a book of this dimension to wish for more deliberate mention of the unifying means of hidden contrapuntal device. Frequently the author alludes to the material upon which such a discourse could have been based. Of a Bach Violin Chaconne he writes: "the nature of the medium prohibits the continuous appearance of the central idea, so that we feel it as there without objectively hearing it." It is this intuitive cogency of the great composers that we would wish had been discussed. Of the Chaconne, Opus 32 by Nielsen he writes:

> It is difficult, except at the climax, to find thematic connections with the main subject; they exist rather with the single line of counterpoint added to this subject immediately after

its initial appearance. Such freedom takes us far from the original form, yet the theme, starkly presented at the beginning, does overshadow the work, however distant the connections may appear on paper. It is this subtle pervasion that makes the title an appropriate one.

It is only because Mr. Rubbra seems so admirably equipped to do so here that we feel disappointed that he does not ponder the question of melodic and rhythmic relevance in composition. The fact that he has prompted the thought is one of the stimulating and significant by-products of his book.

COUNTERPOINT, AN INTRODUCTION TO POLYPHONIC COMPOSITION

by Hugo Kauder
THE MACMILLAN COMPANY, NEW YORK, 1960. 145 p., $5.95

REVIEWER

JOHN A. RITCHIE

This book is intended for students and, in general, follows the traditional paths of species counterpoint over a canto fermo. After a brief discussion of theoretical foundations, there follow larger sections on "two-part setting" with each of the customary five species included, "three-part setting" and "four-part setting" in which some attention is given to double counterpoint. An appendix on the pentatonic scale and "the double scale" concludes the book.

There is probably in existence a body of opinion favouring the teaching of strict counterpoint. Some would prefer a loose amalgam of the species and a concurrent study of 16th century polyphony; a few would align the species with real music of a later period; others boldly assert its disciplinary value regardless of any association with a vital music and teach what might be described as note-spinning fluency. One's first impression is that Mr. Kauder belongs to the latter party. In a

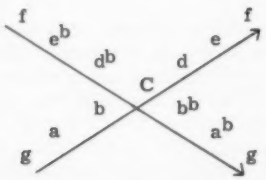
preface he writes: "Counterpoint itself is merely a practical discipline, neither a theoretical nor a historical one." But he also refers to the archaic inhibitions which "the ghost of strict counterpoint" has imposed upon the teaching of musical composition for two centuries.

When, in fact, we reach the more didactic section on two-part work, we are confronted with illustrations that could have come from any text since Fux (except for the somewhat freer attitude to fifths by contrary motion and that old war horse, the consonant fourth). It is all very "C-majorish" and appears to belie the statement that "the traditional method of counterpoint teaching has been adapted here to the new principles of tonality."

Generally there is less restriction placed on the student than usual. But there is one with which most teachers would agree, namely "when the counter-note becomes a dissonance, i.e. a suspension, it has to be resolved by moving one step downward, into a consonance on the next light beat." However, Mr. Kauder himself does not always obey his own strictures. Seven pages later, two examples occur, in consecutive bars, of resolutions within the beat. On p. 88 there are a few more, one of which has to be divined by realizing that the illustration on the top of the page actually follows on from page 89. It is not so much a case of right or wrong, as one of confusion in the student's mind. The difference between $\frac{2}{2}$ and $\frac{4}{4}$ is a real one. In the cases cited no doubt is possible.

Mr. Kauder dispenses with barlines early, a practice which has something to commend it. But often his illustrations gain nothing from this and are difficult to read. When such a procedure is applied to a Bach chorale in open score with the accents marked (on all first beats) it smacks of a novel pedantry.

It is the double scale "here dealt with for the first time altogether" that attracts attention:



Early in the text it is described as the "combining of two opposite basic scales on one tone," resulting in "one hermaphroditic double scale of eleven tones." We learn that "in the resolution of the double scale, the tones of the ascending scale occur only in ascending direction, those of the descending scale only in descending direction." For illustration, Mr. Kauder offers some melodic minor treatment from the opening to the slow movement of Brahms' Fourth Symphony and Bach's C minor Fugue from the Well Tempered Clavier, Vol. I, which only confuses the issue since the last eighth note in bar 1 of Example (a) on p. 10 is noted as A^{b} instead of A.

Nothing of this nor of Mr. Kauder's own examples in the appendix bear on any "new principles of tonality." Neither do they give substance to the statement that "tonality is no more recognized as a principle of general validity." They make pleasant sounds firmly based on a system of tonality accepted by all. In a volume so liberally provided with exercises and illustrations, there is much of value for an inquiring student, but a thorough study of the text could well be a confusing experience.

MUSICAL THOUGHT
by Carlos Chavez
HARVARD UNIVERSITY PRESS, 1961. 118p.

REVIEWER
HALSEY STEVENS

This volume is the fruit of Carlos Chavez' appointment to the Charles Eliot Norton Chair of Poetry at Harvard University, where he delivered a half-dozen lectures on various aspects of music in 1958-59.

Considering the scope of the already published Norton lectures

of Stravinsky, Hindemith, and Copland, one may sympathize with the new incumbent who finds it increasingly difficult to say fresh and original things about music, even though his musical ideas may be both fresh and original. Chavez had the ill luck to follow three of the most articulate of his fellow composers, and since he is apparently not a penetrating thinker about music he is at a singular disadvantage. His lectures are chatty and pleasant, but rarely informative. They have the air of having been put together for a musically inexperienced audience interested only in acquiring a few basic ideas about the art. The result, unfortunately, is that Chavez discloses to the musician little but the obvious.

In the present context four of the book's six chapters may be passed over quickly: "A Latin American Composer," which never becomes specific in relation either to Chavez himself or to any other composer; "Art as Communication," "Composer and Public," and "The Enjoyment of Music." All retrace ground already thoroughly covered and hardly in need of fresh light. In any case, no such light is shed. Consider the following excerpt:

> If Beethoven's Ninth Symphony is a far more complex organism than any musical piece of twenty-five hundred years ago, it is because modern man is more complex also. (p.25)

This statement, characteristic of many throughout the book, is facile and superficially unobjectionable, if oversimplified. But it ignores structures far less complex though contemporary with or later than the Ninth Symphony. The possibilities of complexity have grown with the intellectual and esthetic development of man; the necessity of complexity has not yet been clearly demonstrated. Chavez' "because" is a non sequitur.

The remaining two chapters have titles that seem to justify consideration in this journal: "Form in Music" and "Repetition in Music." These, too, are disappointing. The author's main thesis is that "Rhythm and symmetry are the essentials of musical construction" (p. 47); that both are forms of repetition, and that repetition is the "shaping force" of music. Rhythm he describes (disclaiming any pretense of definition) as "an adjective quality of a series of (a) equal divisions in time or space, (b) having prosodic accents at equal distances"; symmetry as "an adjective quality implying (a) the existence in time or space of two or more equal or identical elements, (b) placed at equal intervals or distances."

A rhythm of prosodic accents at unequal distances is apparently anomalous to Chavez, and a good deal of recent music is — by his interpretation of the term — unrhythmic if not actually antirhythmic. A musical structure asymmetrically disposed is likewise anomalous.

> The emancipation of conscious thought, the emancipation of logic, implies the emancipation of archetype forms and academic logic. That would be quite an experience! (p.50)

Such an emancipation Chavez compares at some length and somewhat irrelevantly to surrealism in the graphic arts, without reaching any tenable conclusions. He believes that atavism, having "rooted symmetric rhythmical patterns very deeply in our subconscious," prevents "unbiased thought," and that to permit the free play of "creation" (which he considers subconscious, as opposed to the conscious ordering and organizing which constitute "composition") we should have to root out the atavistic automatism that would interfere with it. The author refuses to commit himself to such a remote possibility.

If the chapter on "Form in Music" skates gingerly over basic issues, that on "Repetition in Music," despite its numerous tables, charts, and musical examples, becomes little more than an exercise in note-counting. Beethoven and Stravinsky are the masters cited at length. The conclusion reached is that "all the constructional devices based on repetition and symmetry" are still valid; and that "any departure from repetition would result in unconvincing music, wanting in unity and form." (p. 79) The author discusses repetition as "a way of making oneself understood quickly and unmistakably," repetition as the chief expedient in the drive for unity, and repetition as "the condition of symmetry." (p. 77f) Only at the very end does he open the door to allow us a glimpse of other realms:

> The idea of repetition and variation can be replaced by the notion of constant rebirth, of true derivation: a stream that never comes back to its source; a stream in eternal development, like a spiral, always linked to, and continuing, its original source, but always searching for new and unlimited spaces. (p.84)

Having had the imagination to envision such a music, Chavez turns his back on it, leaving its possibilities unexplored. Two sentences further on he closes the chapter and the subject. There is obvious danger in such a never-ending musical stream: what is to prevent its becoming amorphous from be-

ginning to end? The conventions of return after digression seem to pull as strongly now as ever; nevertheless the prospect Chavez hints at is an interesting one to contemplate.

MUSIC AS METAPHOR: THE ELEMENTS OF EXPRESSION

by Donald N. Ferguson
UNIVERSITY OF MINNESOTA PRESS, 1960. 198p., $4.75

REVIEWER

GLEN HAYDON

In considering music as metaphor Ferguson looks for the manner in which music may be the vehicle for the expression of something beyond itself. He sees the need of his investigation because he feels, perhaps even fears, that music without this reference would be lacking in vital relations to life situations. Such relations he regards as essential to all significant art. He cites an example of a poem which gains in value because of the seriousness of its theme, over and above its technical perfection in construction. Music, he feels, cannot represent non-musical references directly, but must make the connection by indirection.

This process of indirection he labels as metaphor. The tonal-rhythmic patterns of music correspond to the kinetic-visceral patterns within the body that, according to psychologists, are characteristic of the emotions. These patterns are evoked in the listener by music and the individual relates them to "life situations." Thus music becomes "expressive" of something not in itself music. That something is the meaning of music. The capacity of a given piece of music to evoke meanings in this sense must be taken into account, according to Ferguson, as a significant factor in musical criticism.

The semantic difficulties involved in the discussion of such an

intricate problem are so great that one hesitates to enter upon a more detailed analysis of the book. But the main thesis is reasonably clear. Each reader's evaluation of the significance of the study will no doubt depend on his general viewpoint with regard to the autonomous-heteronomous problem of musical aesthetics. As one who leans toward the autonomous viewpoint, this reviewer is not convinced by the analyses and arguments presented. His own interpretation would be that if the emotions evoked are, in the listener's experience, kept relevant to the music, an enrichment of the aesthetic experience may be possible. But, if the attention of the listener is diverted from the music to the contemplation of any "life situations," the aesthetic experience may suffer, may fall to a lower level of excellence than not. In short, this reviewer's viewpoint is that "intrinsic, autonomous musical meanings are direct and primary, and afford the principal criteria of musical value; and that extrinsic, heteronomous meanings are indirect and secondary, and can afford only subordinate criteria of musical value."†

The book is obviously the work of a man widely experienced in the field of music, of one who has thought and read much about the problems of musical aesthetics. One cannot help feeling, however, that, time and again, the author gets into various semantic, not to say, logical, difficulties, from which he scarcely escapes unscathed. He seems not to be unaware of these difficulties, and he makes constant reference to them and persistent efforts to avoid them. But, although one can agree with much of his analysis, he may still draw rather different conclusions. There is a great deal of interesting reading in the book, and students of musical aesthetics will doubtless find it worth examining. One cannot help sympathizing with the author's efforts, even if he cannot agree with his main thesis.

†See p.23 of the reviewer's essay, On the Meaning of Music. (Washington, D.C., Library of Congress, 1948).

SINCE DEBUSSY: A VIEW OF CONTEMPORARY MUSIC
by André Hodeir, translated by Noel Burch
GROVE PRESS, INC.,1961.

REVIEWER
A. F.

When we compare the contents of this book with its title we can only conclude that at the time of writing the author had accidentally put his bifocals on upside-down, for the view he describes is strangely distorted. Part of the difficulty may stem from the enormous scope of the subject, and therefore we hasten to point out that the author — who, according to available information, is a reformed jazz pianist — has undertaken a survey of the whole of recent music history. But what would appear to be a formidable task becomes child's play in the hands of M. Hodeir. He has the gift of simplicity.

The central part of the book contains eight chapters, each one dedicated to the work of a single composer. In the first five M. Hodeir comes to terms with as many major figures of the older generation: Stravinsky, Schoenberg, Berg, Webern, and Bela Bartok. In the three subsequent chapters he discusses the work of Messiaen, Boulez, and a less familiar composer, Jean Barraqué, about whom he is reverently ecstatic. In a hushed voice M. Hodeir confides that out of respect for Barraqué's unpublished essay on Debussy he has decided to limit his discussion of that composer's fundamental contribution, a contribution which is indicated in the title of the book. M. Hodeir shows markedly less respect for historical accuracy. For example, on page 37 we read: "The discovery of equal temperament at the beginning of the eighteenth century was one of man's least trumpeted yet most outstanding victories over nature." Had he consulted a reliable source he would have found the correct approximate date of "discovery" to be some two centuries earlier.

The author's view of more recent music history is similarly beclouded — but hardly unique. Thus he parrots the notion that

Schoenberg's Short Piano Pieces, Op. 19, were inspired by the miniature works of Webern, evidently unaware of Schoenberg's three diminutive compositions for chamber orchestra (1910), which may well have influenced Webern in the direction of the miniature form. More serious is the author's perpetuation of the myth that Boulez was the first composer to extend serial technique to musical elements other than pitch. He even includes a statement to this effect in the Glossary under the heading "Row or Series." We quote: "Since Boulez this serial principle is commonly applied to the other components of music: series (or rows) of block sonorities, time-values, attacks, intensities, etc., may be employed simultaneously." M. Hodeir asserts that the first instance of such extension is Boulez' Polyphonie x, a work which dates from 1950. This is wholly incorrect. The first composer to extend serial technique to elements other than pitch was Milton Babbitt. He did this in his Composition for Four Instruments (1946-47) and, at approximately the same time, in his Three Compositions for Piano. In both works, rhythm, dynamics, and register are serially organized.

Lest any of our "advanced" American composers lose heart because of this treatment of Mr. Babbitt and harbor ill feelings, we hasten to say that M. Hodeir deserves eternal gratitude for bringing to their attention the following fact: "Wealthy, powerful foundations [in America] subsidize organizations whose avowed aim is the propagation of modern music." Readers who are unable to verify this immediately or those who desire a more detailed explanation are referred to M. Hodeir. The author's description of American music altogether reads like an inept and extended paraphrase of Rousseau's famous statement:

...je conclus que les François n'ont point de Musique & n'en peuvent avoir; ou que si jamais ils en ont une, ce sera pis pour eux. [I conclude that the French have no music whatsoever, nor are they capable of having a music. And if ever they do have one it will be the worse for them.]

We have not yet done justice to M. Hodeir's original thought. Much of this appears to be generated by "Angst," for M. Hodeir's musical world is dominated by a sinister force, by what he refers to as Neoclassicism. Peering through his inverted bifocals M. Hodeir sees himself and his coterie surrounded by neoclassicists, progeny of the grandfather neoclassicist, Stravinsky. He squints toward America and makes out an enormous confraternity of neoclassicists, among them Elliott Carter (also characterized as a "newcomer"), Stefan Wolpe,

and that arch-neoclassicist, Milton Babbitt. There are even hints that Boulez himself may have hidden neoclassical tendencies.

M. Hodeir's "Angst" concerning Neoclassicism perhaps is only part of a larger concern, an existentialistic concern for the general health of the culture. This may explain his penchant for violent metaphor, such as that on p. 44: "The Chamber Symphony of Schoenberg, though aesthetically a minor work, constituted, historically speaking, a healthy, double-barreled reaction against the two main forms of post-romantic gigantism." This kind of historico-musical observation often causes the author to make unlikely diagnoses such as the following (p. 45): "Discarding the conjunct motion dear to the classicists and pre-Wagnerian romantics, Schönberg began to make systematic use of the hitherto rarely used disjunct interval, incorporating it in his polyphony. Though this concept did promote a kind of hyperlyricism in the melodic line it also gave rise to contrapuntal conflicts which in turn created a permanent sense of tension." We may also take this excerpt to be typical of the reversible pronouncements of The New Criticism; the concept could just as well have promoted hyper-tension in the melodic line, leading in turn to a permanent sense of lyricism.

But M. Hodeir is not completely obsessed with the violent and morbid. Love occupies a prominent place in his thought. Thus he writes: "Webern was the first composer since Debussy to have been in love with sound for its own sake, and this fact was to condition his whole style of composition."(p. 75) And further on: "Bartok was in love with dissonance, but the acid harmonic idiom in which he gave vent to this passion was somewhat crude." (p. 92) (The latter sentence also illustrates M. Hodeir's astonishing gift for vivid writing.) But whereas most of M. Hodeir's composers are enamoured of some aspect of their work but presumably are frustrated to some degree, the passions of his hero, Jean Barraqué, flow freely. He tells us that "in the first interlude [of Barraqué's Sequence] ...the tension which, until this point, has not been exteriorized bursts forth in a brief percussion solo." And on the same page (p. 178) he describes M. Barraqué's solos as "splendid geysers gushing forth now and again, whenever the underlying tension becomes too great." If M. Hodeir's encomium of Jean Barraqué gives the unfortunate impression that it is only a case of "lancer quelqu'un" we must realize that in his view change of hero is an evolutionary, nay, a literary necessity. Music too must have its New Look. This leads us to suggest

that should the French establish a Chambre Syndicale de la Couture Musicale they would do well to consider appointing M. Hodeir as director — unless of course he begins to exhibit symptoms of Neoclassicism in the meantime.

RECENT BOOKS AND ARTICLES

books

APFEL, ERNEST
Studien zur Satztechnik der mittelalterlichen englischen Musik
HEIDELBERG:C. WINTER 1959. 107p. & 145p. DM 49.

BENADE, ARTHUR H.
Horns, Strings, and Harmony
DOUBLEDAY 1960. 271p. $. 95.

CASTIGLIONI, NICCOLO
Entstehung und Krise des tonalen Systems
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abbreviations:

AM	Acta Musicologica
JAAC	Journal of Aesthetics & Art Criticism
JAMS	Journal of the American Musicological Society
JMT	Journal of Music Theory
MF	Die Musikforschung
MQ	The Musical Quarterly
MR	The Music Review
RM	La Rassegna Musicale
RMC	Revista Musical Chilena

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LETTERS TO THE EDITOR

Sir:

In the November 1960 issue of the Journal of Music Theory Hans Neumann criticizes Ernst Oster for, in turn, having criticized Felix Salzer for departing "from his [Schenker's] principles without informing the reader of the exact points of departure."† According to Neumann, Salzer's principal deviation lies in the application of Schenker's theories to music outside the period Schenker dealt with (roughly 1700-1900). Neumann feels that insofar as Salzer clearly delineates this modification (see p. xvi-xvii of Salzer's book, Structural Hearing), he should not be "obliged to account for every single departure from dogmatism and orthodoxy."

Actually, Salzer departs significantly from Schenker even in analyses of music of the 18th and 19th centuries. These differences are illustrated in conflicting interpretations of the same works. Identical sections of Chopin's Mazurka, Op. 30/4, his Nocturne, Op. 9/2, and the first movement of Beethoven's Sonata, Op. 10/1 are analyzed both in Structural Hearing and in Schenker's Der Freie Satz (Universal Edition, Wien, 1935 and 1956). At issue are basic concepts such as the constitution of background structural chords and closure of the fundamental melodic line. Salzer shows the final note of the fundamental melodic line of the Mazurka to be E ($\hat{3}$), not C# ($\hat{1}$), as Schenker indicates. Salzer corrects Schenker's reading of a structural V in bar 148 of the Beethoven; he puts it in bar 158. In a background graph of the Nocturne (Ex. 500b), Salzer suggests a I II V I progression after the interruption (bar 21), as against Schenker's simpler version: I V I. Unfortunately, Salzer does not compare his analyses to Schenker's. We are left to surmise that one or both of the theorists erred in application of the same theory, or that they do not agree about basic principles at the outset. Or are we to assume that for a given piece more than one analysis is feasible?

†See Salzer's Structural Hearing, New York, Charles Boni, 1952. Mr. Oster's article appeared in the April 1960 issue of this Journal. Ed.

Salzer claims that any given phrase or section of a piece may be treated as a separate entity, having its own structural progression. But when the phrase is taken in the context of the total work it may amount merely to a prolongation within the work's primary structural progression. (See Structural Hearing, p. 12 and 22-3.) For a given chord succession to be interpreted simultaneously as progression and prolongation seems illogical. Was this Schenker's approach too? It certainly leads Salzer into difficulty even in the first example in his book. Treating as a unit the first two bars of the Bach B♭ major Prelude, WTC I, Salzer finds one of the "basic progressions," I II V I. (See p. 15 of Structural Hearing for a discussion of basic progressions.)

Calling the first few bars of almost any tonal piece a progression is controversial. And it is hard to find the II chord that Salzer suggests. The principal harmonic rhythm is two-to-the-bar. Salzer designates the second harmony of bar 2 as C minor, followed on the last eighth note by yet a third harmony, V7 (also referred to as plain V). The fifth of the previous basic harmonies has appeared, accented, in the alto. Here the note G appears unaccented as part of an elaboration of the soprano note, E♭; at the same time, the bass arpeggiates the F triad, starting on the note C. Salzer looks for a structural chord at this point in the music because it is the climax of a sequence and the occasion of a reverse in the direction of the melodic line. But whether such factors regularly play a structurally determinant role is not ascertained. We cannot be sure of what Salzer — or Schenker — intends.

Roy Travis, whose essay in the November 1959 Journal of Music Theory provoked Oster's article, is one of several writers who cite Structural Hearing as the published source

of their knowledge of Schenkerian techniques. Leonard Meyer, who in his book, Emotion and Meaning in Music, criticizes the concept of prolongation, apparently has read Salzer, but not Schenker. William Gettel (Journal of Music Theory, November 1958) says that an analysis by William Reynolds (JMT, April 1958) agrees with Salzer's view of the same piece, and goes on: "Schenker's school, however, also tends..." Presumably then, Salzer represents Schenker's school. This attitude is confirmed by Mosco Carner (The Musical Times, June 1953), who writes: "[Structural Hearing] presents a complete and systematic exposition of Schenker's ideas." On the other hand, Oswald Jonas, editor of several of Schenker's works, makes sweeping criticisms of the book (see Music Library Assn. Notes, June 1953). Milton Babbitt (American Musicological Society Journal, Fall 1952) says Salzer fails to deal explicitly with some essential aspects of Schenker's thought, but believes it was not Salzer's intention to do so. When Hans Keller acknowledges a partial debt to Schenker for his own concept of functional analysis (The Mozart Companion, 1956), and "W. M." (Music & Letters, October 1953) says that Rudolph Reti's book, The Thematic Process in Music (1951) "may be considered an extension of some aspects of Schenker's teaching" (but not acknowledged by Reti), the English-language student can only wonder what "Schenker" is. He certainly cannot accept outright Nathan Broder's statement (Musical Quarterly, January 1953) that with the appearance of Salzer's book, Schenker's theory is at last available for the reader unfamiliar with it.

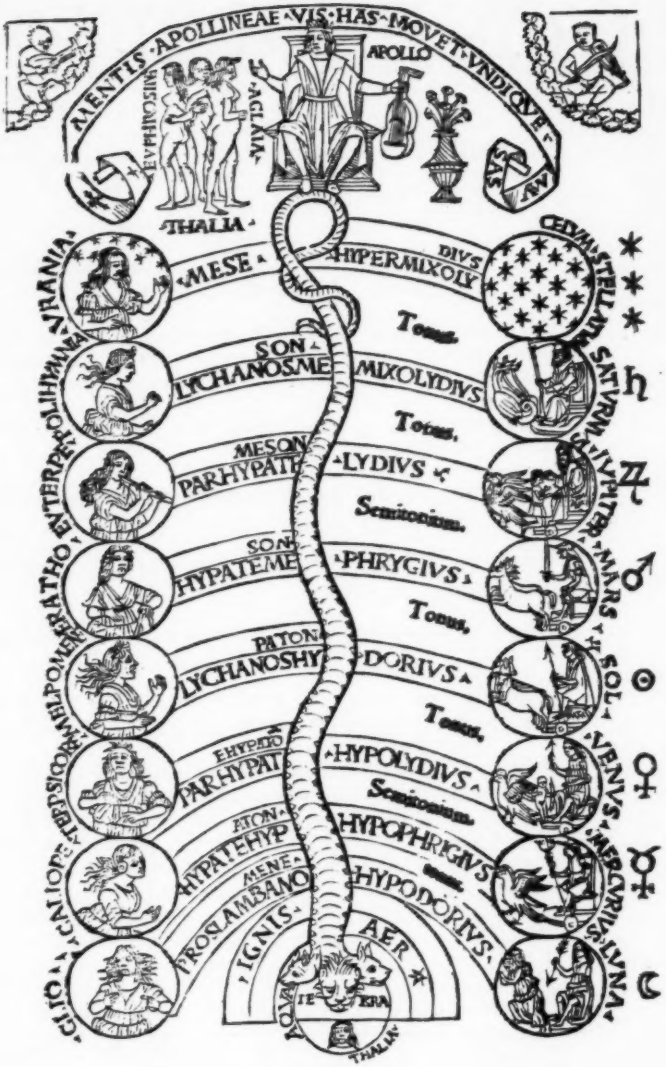
The Gettel-Reynolds controversy, covered in the JMT from April 1958 to April 1959, is a case history of the type of confusion abroad about Schenker's ideas. Both men analyse the first two bars of Bach's B Major Prelude, WTC I, using graphing methods derived from Schenker. They come to opposing, and, in both cases, erroneous conclusions. Reynolds omits the harmony from his sketch, making it impossible to evaluate his portrayal of an underlying melodic motion from B up the scale to F# and back to D# ("b"). Gettel gives all the voices, but demonstrates an arpeggiation of the tonic triad, from B through D# to F#, and back to D# ("c"). Both writers give undue emphasis to the F# and treat the first and second E's as passing tones between D# and F#. In fact, the first E functions as upper neighbor to D#, and the F# and second E serve to ornament the first E (See "d" by the present writer). Moreover, Reynolds and Gettel equate the term "foreground" with the actual music itself. According to Schenker, the foreground is represented in the first reduction, in which ornamental detail is removed. This is only the first step in analysis. (Certainly Schenker did more than teach us to distinguish passing tones, etc.) Next comes the crucial middleground sketch, which evaluates the material from the foreground level. (The "background" is hardly an issue for an excerpt as short as this.) In the analysis below by this writer, short slurs indicate rhythmic groupings, long slurs the over-all melodic direction of the two upper parts. Durational values indicate degrees of importance of notes relative to each other.

The ascent of a 3rd in the top voice is supported by an ascent of a 6th in the lower voice. The soprano D# is not established until the third beat of the second bar instead of the third beat of the first bar, because the alto needs more time to reach its goal, B. Thus the function of the neighbor tone E, which waits out the lower voice motion from D# to B. To produce added emphasis, the E is itself ornamented, providing still another beat of tension before the climax on D#. A thorough middleground sketch will frequently show a commonplace event (as here, a 6th becoming a 3rd) and the particular, often unique, way it is treated by the composer in the piece under consideration. A foreground sketch will rarely provide enough informa-

tion to substantiate final statements about structural content. It is noteworthy that one of the "essential aspects of Schenker's thought" that is not sufficiently stressed by Salzer, according to Milton Babbitt, is this very concept of structural levels (Schichten). The argument between Gettel and Reynolds calls to mind a musician who once solemnly assured me that Beethoven's music is based on the scale, that Bach's is based on the arpeggio, and that Beethoven is therefore the superior composer! Small wonder if experienced musicians who come into contact with ideas of this sort shrug their shoulders at the mention of the name of Schenker. This situation would be rectified if Schenker could speak for himself!

Ernst Oster is right, then, to decry the lack of a reliable critical edition of Schenker's works in English. Salzer has indicated the difficulty facing the unaided novice who would study Schenker in the original. Therefore, a proper English edition would have to be more than a literal translation; it would require extensive annotation of the basic text. This is not the same as adaptation, however. While it is not Salzer's responsibility to undertake this task, he could assist matters by clarifying his departures from Schenker, and by presenting any further development of his ideas since the publication of his book nearly ten years ago. In recent years, authoritative translations of treatises like Fux's Gradus ad Parnassum (Alfred Mann, tr., New York, 1943) and C.P.E. Bach's Keyboard Essay (William Mitchell, tr., New York, 1949) have appeared in English for the first time. Let us hope we will not have to wait another two hundred years for suitable translations of Schenker!

Arthur Komar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